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The Representation of Architectural Space for Caspar David Friedrich: The Case Study of Eldena Abbey

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Abstract: The spatiality of Caspar David Friedrich's paintings has always been a topic of investigation within the field of Romantic art history. This research has been conducted with the objective of gaining insight into the ideas and reasoning of the Greifswald painter. The influence of new insights into Caspar David Friedrich's spatiality construction has led the scholarship to trigger different ways of interpreting his paintings and artworks. The aim of the proposed study is to analyse the architectural spatiality as defined by Friedrich in his paintings that have Eldena Abbey as their main architectural reference, using a methodology that uses 3D digital modelling as its main tool, in order to understand if the painter used any spatial compositional patterns in these paintings. Another objective of this study is to verify the potential of 3D modelling as an analytical tool for the architectural spatiality of Caspar David Friedrich's paintings. An analysis of the spatiality of the church designed by Frederich has been carried out through the reconstruction of the central nave of the religious space, as an example of the compositional patterns that will eventually be detected in his representation of Eldena Abbey. In this research, 3D modelling is a fundamental analytical tool used for reconstructing the spatiality of the church as represented by Friedrich in three artworks that have Eldena as their main reference for the architectural motif. This research uses the projection of the apparent contour to reconstruct the position and size of the depicted architectural elements within different reconstruction scenarios. The possibility of using a compositional benchmark as the ratio between the width of the column and the following intercolumnar distance allows using the identification of compositional patterns within the analysed artworks in order to understand how Friedrich conceived architectural space within them.

Keywords: 3D reconstruction; Caspar David Friedrich; digital art history; architectural spatiality; Eldena Abbey; *Abbey in the Oakwood*

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1. Introduction

1.1. 3D Reconstrunction and Romantic Paintings' Spatiality

A very brief part of the study presented in this article was presented and published as an abstract at the DH 2024 Conference, held in Arlington from 6 to 9 August 2024 (Esposito 2024, pp. 174–179). The research on the analysis of the spatial construction of the painter Caspar David Friedrich is part of a broader field dealing with the concept of spatiality in the context of Romantic painting. Scholarship on art history has concentrated on the analysis and interpretation of the spatiality of Romantic painting. With regard to Friedrich, a number of specific studies have addressed his spatial construction (Rzucidlo 1998). The depth of space in the case of the Greifswald painter is defined through the composition of the landscape scene, which juxtaposes elements in a manner that progresses in depth.

The structuring of these elements in the direction of the vanishing point emphasises the perspectival character of the representation.

The definition of the vegetation in Caspar David Friedrich's representations is also elaborated with a diversification of its volume in relation to the depth of the scene. This diversification is evident in the representation of trees, which are represented as lusher in the foreground and slimmer in the distance (Rzucidlo 1998, p. 114). The spatiality defined by the Romantic painter is also generated by a conception of the vision of reality that the artist wishes to transfer within the dimension of the elements that constitute the artwork's structure. This definition of spatiality involves the distinction between background and foreground scenes. Indeed, the transition between distinct spatial zones in depth is one of the elements that distinguish spatial composition in the landscape paintings of the Greifswald painter (Homberg 1974, p. 134).

Caspar David Friedrich is considered the leading exponent of the Romantic movement. He was born in Greifswald in 1774 in what was then the Kingdom of Sweden (now Mecklenburg-Vorpommern, one of the 16 German states). His childhood was marked by the loss of his mother (1781) (Grave 2012, p. 276) and his younger brother, who had tried to save him while they were skating on ice in Greifswald (1787) (Grave 2012, pp. 75–76). This episode left an indelible mark on his life and, in particular, on his artistic production. Between 1790 and 1794, he studied drawing and representation at the University of Greifswald, where he attended lectures by Johann Gottfried Quistorp. After completing his studies, he moved to Copenhagen to attend the Academy of Fine Arts, spending the next four years in Berlin and Dresden. In 1798, he settled here to attend the academy of arts. During his stay in Dresden, he visited the Saxon Switzerland and found inspiration for his beautiful landscapes. Between 1798 and 1810, he met many painters, writers and artists in Dresden, Berlin, Greifswald, Neubrandenburg and Weimar. These included Johann Philipp Veith, Philipp Otto Runge, Ludwig Tieck, Johann Wolfgang von Goethe, Friedrich Schleiermacher and many others. During this time, he visited many of the places he would later depict in his work, such as the island of Rügen, Neubrandeburg, Greifswald, Dresden and the nearby town of Pirna, where he lived for a short time. In 1810, the Academy of Fine Arts in Berlin held an exhibition of his paintings *The Monk by the Sea* and *The Abbey in the Oakwood*, which was a great success with the public and illustrious personalities; King Friedrich Wilhelm III of Prussia bought the two paintings. In 1811, several of his paintings were exhibited in Weimar, where he came into contact with the elite, including the Prince of Weimar, and with German intellectuals in Jena. He later left Dresden because of the French invasion but returned the year after its liberation in 1814.The painter remained on the move throughout his life; Dresden was the main city in which he settled, but he also travelled frequently to his home town of Greifswald and to Rügen, where he found inspiration for some of his work as well as refreshment during periods of convalescence (Grave 2012, p. 276).

In 1817, he met and became friends with the painter Carl Gustav Carus, for whom he was one of the main figures of confrontation. In 1818, he married Caroline Bommer and, on his honeymoon, visited Stralsund and Greifswald, where he was reunited with many members of his family, including some of his brothers. The watercolour *Der Greifswalder Markt*, in which the painter depicts his relatives with their children and partners in the market square of his home town, dates back to this period. In 1824, he became a professor at the Academy of Fine Arts in Dresden, without teaching duties, partly due to his poor health, and was criticised for this position in later years. In the last years of his life, the painter struggled with his poor health and financial problems that increasingly limited him. In the last years of the 19th century, he came into contact with intellectuals and members of the Russian royal court. In 1835, he suffered a stroke that further complicated his precarious

health. He died in Dresden in 1840; a year earlier he had received a visit from the painter Caroline Bardua and his friend the painter Carl Gustav Carus (Grave 2012, p. 277).

In light of the aforementioned studies on Friedrich's spatial representation, the following proposal aims to delineate the qualitative and quantitative outcomes that facilitate an analysis of the ways in which Friedrich conceptualised architectural space in works that appear to be primarily inspired by Eldena Abbey. To illustrate this process, we focused on the spatiality of the central nave of the church designed by Frederich.

Regarding the proposed study, we believe it is important to clarify the questions we aim to address in this contribution.

- In the field of architectural representation, how did Caspar David Friedrich represent the architecture of the monastery of Eldena?
- How could 3D modelling be a reliable tool for the analysis of the architectural spatiality represented by Caspar David Friedrich?
- Is it possible to detect any compositional pattern in the architectural spatiality depicted by Friedrich in the artworks that have Eldena as their main reference?

1.2. The Representation of the Architectural Subject and the Eldena Monastery by Caspar David Friedrich

This section will concentrate on analysing how Friedrich represents the theme of architecture in his work, as well as examining the approach and stylistic motifs he employs in portraying this subject matter. The proposed study aims to explore and identify possible compositional patterns within the architectural motif represented by Friedrich, using a methodology that considers 3D digital modelling as the main analytical tool. In order to carry out this analysis, the nave of the church has been identified as an effective part to exemplify the analysis of Friedrich's way of addressing the motif of the depth of architectural spatiality. The methodology presented in the following part of the article is applied in the digital environment of the 3D-modelling software Blender (version 3.4). The aim of this study is to investigate the compositional schemes used by the painter to organise the depiction of this architectural motif in depth.

In the scope of romantic depiction, the representation of architecture, and ruins in particular, has always been considered a key motif, due to the compositional choices made by the artists in the characterisation of the architectural motif. Caspar David Friedrich is no exception, and his depiction of architecture and ruins has been studied in depth, sparking a lively debate on the reception of North German Gothic architecture as one of the interpretive issues in Friedrich's artworks (see Scholl 2007).

From the first decade of the 19th century, we can observe how Friedrich became interested in depicting architecture in addition to drawing and painting naturalistic motifs. It is assumed that, already, his first drawing teacher, Quistorp, was one of the figures who inspired him to pursue this subject. Quistorp also encouraged him to depict other naturalistic elements, including rock formations, trees, boats and seascapes (Gärtner 1990, p. 107).

During the early 19th century, Friedrich might have been influenced by figures such as Friedrich Gilly and Karl Friedrich Schinkel, who were involved in depicting ruined and medieval architecture in Germany. Among them, it is important to mention the representations of the church in Kolbacz and Malbork Castle. Gilly provides a detailed description of the different sections of the wall surfaces in order to render the brick texture of the represented building. Schinkel, on the other hand, did not focus on the representation of the bricks in his drawings of the Chorin monastery (Scholl 2007, p. 182).

It is worth mentioning that the representations of the Treptower Gate in Neubrandenburg and the chapel in Wrangelsburg by Caspar David Friedrich provide a clear idea of

how the painter envisioned the representation of architecture, especially the rendering of traditional brick masonry (Scholl 2007, p. 181). From this point of view, Scholl, in his article "*Ruinen-Versetzungen: Das Eldena-Motiv und die Rezeption der Backsteingotik bei Caspar David Friedrich*", describes how the painter's way of depicting buildings was to emphasise the parts of the brick surface with stronger shading (Scholl 2007, p. 182).

For instance, the traces of the beams create a highly recognizable shading that gives a strong sense of volume to the surface. In general, Friedrich's method of representing traditional brickwork is summarised by a series of parallel lines that emphasise the continuity of the mortar joints defining the brick texture (Scholl 2007, p. 181).

The representation of this type of masonry varies from artwork to artwork. In Friedrich's architectural sketches, it is easy to notice the painter's interpretation of the architectural matter. However, it should be pointed out that some of the tendencies and characteristics of this representation of the masonry are striking in some of the drawings that Friedrich elaborated in Wrangelsburg and Neubrandenburg (Scholl 2007, pp. 181–82).

The way Friedrich captures Eldena Monastery is not focused on providing a strictly archaeological description of the Eldena Abbey site at the time of the representation. Instead, it aims to offer the observer an interpretation of the state of the ruins. Scholl defines his approach to the representation of ruins as 'fictitious archaeology' ("*fiktiven Archäologie*"—(Scholl 2007, p. 182)), in which the representation of the ruins and their narrative is influenced by the interpretation and conception of the artist (c.f. (Scholl 2007); see also (Gärtner 1990)). Caspar David Friedrich systematically represented not only the Eldena Abbey but also other monasteries and religious complexes such as the Oybin Monastery and the Jakobskirche in Greifswald. The latter, in particular, becomes a further example of the idea of the representation of architecture, which, in Friedrich's transposition of it in the painting *Cloister Cemetery in the Snow (Klosterfriedhof im Schnee)*, reproduces and elaborates the original architectural appearance in a wreck-like style (Gärtner 1990, p. 112).

However, the relationship that distinguishes Friedrich's artistic work is certainly the one that binds him to the monastery of Eldena, as it has been one of the main references in the Greifswald painter's work since his earliest artistic experiences (Schmitt 1943, p. 10).

In 1801, Caspar David Friedrich returned to Greifswald from Dresden. During this period, he focused on representing the monastery, specifically the eastern side of the church with the ruins of the transept. In the watercolours and sepia drawings of this period, Friedrich's maturity is evident, particularly in his depiction of architectural structures. One of these drawings, preserved in Stuttgart[1], showcases his attention to detail in the masonry ruins, whose wall surface characterisation has been accurately depicted in terms of material description. This drawing appears to be the reference for a sepia drawing preserved in Würzburg (according to Schmitt's publication on p. 19 (Schmitt 1943))[2]. The painter located picturesque scenographic elements to enhance the perception of the architectural motif, which is displayed as the background for the narrative of the depicted scene. The brazier, placed in the centre of the scene, illuminates the ruins creating *chiaroscuro* effects and drawing attention to the representation of the red brick ruins. Drawings from around 1803, belonging to the cycle called '*four seasons*', are also taken into consideration, including the painting '*Winter*', which has been reproduced in two versions—one kept in Berlin[3] and one in the *Kunsthalle* in Hamburg[4].

In those two drawings, the manipulation of the proportions of the elements depicted in the nave of the church of Eldena is strikingly different. The proportions of the pillars and central window of the west facade of the church in the drawing kept in Berlin are much more emphasised than those of the drawing stored in Hamburg. There has also been significant alteration of the depicted architectural elements, and in particular, some of the church's structural features have been represented while others have been overlooked.

Moreover, the view has been heavily altered by Friedrich, including a seaside landscape, and a view of the church from the north has also been included (Schmitt 1943, p. 17).

The way Eldena has been represented by Friedrich is thus related to the aforementioned concept of '*fictive archaeology*', in which the painter takes an architectural reference and reinterprets it for his own expressive purposes (Scholl 2007). In Schmitt's publication, '*Die Ruine Eldena im Werk von Caspar David Friedrich*', there is an excursus of the various representations of the Eldena monastery by the artist (Schmitt 1943).

This excursus in the literature on the reception of the architectural representation of Eldena in Friedrich's works makes it possible to understand how he interpreted this reference differently during the different phases of his artistic life.

1.3. The Studied Artworks and the Influence of Architectural Spatiality on Their Reception

In this section, we will focus on the main works of art that depict Eldena Abbey, in order to understand how the architectural spatiality represented has influenced the interpretation of these works of art. This study will focus mainly on three works that refer to the church of Eldena and whose dates correspond to different periods of Friedrich's biography: *Abbey in the Oakwood* (dated 1809–10), *Ruined Monastery of Eldena near Greifswald* (dated 1825) and a watercolour dated 1836 *The Eldena Abbey in Greifswald, 17th March 1836*[5], which takes up the structure of the painting mentioned above. The technique of representation varies between the three works: the first two are oil paintings and the third is a watercolour. It is important to emphasise this difference because, according to Scholl, in his oil paintings with Eldena as a reference, Caspar David Friedrich did not set himself the expectation of depicting the church as it was at the time (Scholl 2007, p. 180). In fact, the artworks considered for this study exhibit compositional choices that result in a rework of the architectural organism, or, at least, a reinterpretation of the architectural space delivered by the painter.

Beyond the representation of materials described in the previous chapter, Friedrich's reproduction of the masonry surfaces, the conception of the spatiality of these works, as defined by the brick wall surfaces themselves, very clearly influenced the political and religious interpretation and reception of Gothic architecture in Germany (see also Scholl 2007). Various studies and analyses of the spatiality of the church of Eldena as depicted by Friedrich have led to changes in the interpretation of his work. In particular, Scholl's article (Scholl 2007) cites the opinion of Zimmerman (Zimmermann 2000), deepened by Timm's article (Timm 2004)[6] as one of the studies in which the use of reflectography can lead to a revision of the interpretation of the German painter's spatiality. In particular, some scholars, such as Schmitt (Schmitt 1943, p. 9) and Möbius (Möbius 1980, p. 10), considered that the gothic portal in the painting *Abbey in the Oakwood* was embedded in the western façade of the church, and that the processional scene depicted in the painting indicated the monks' departure from the religious space. Subsequent studies have identified a discontinuity between the surface of the west façade of the church, with its large Gothic window, and the surface of the portal. This is due to the presence of a frieze that could not be located on the counter-façade. Reflectographic analyses from the early 2000s revealed the spatial structure created by Friedrich (cf. Timm 2004). The analyses distinguished between the two surfaces of the façade and the portal, and also identified a deeper spatiality in the nave of the church. This discovery led to a novel approach to the reception and interpretation of the role of the church spatiality in the painting (Scholl 2007, pp. 189–90). As a result, the reception of the work became a topic of discussion due to the significant change in the narrative of the represented scene. The funeral procession that, according to the previous interpretation moved away from the ecclesiastical space, ends at the west façade of the church in this arrangement. The architectural element defined the space of the church as a positive

environment for the funeral procession of the monks (Scholl 2007, p. 190). This contrasts with Friedrich's representation of architecture in paintings such as *The Cathedral*, where the Gothic façade represents an unreal vision whose architectural characterisation is barely alluded to (Grave 2013, pp. 321–25). This emphasises the importance of studying the meaning of spatiality, especially in relation to this painting, from an art historical perspective, as the spatial arrangement of these paintings strikingly influenced their reception.

There is a drawing from 1803 that is considered to be the link between several representations of Eldena, including the two previously mentioned versions of *Winter*, and indeed there are many similarities between this drawing[7] and these different versions of *Winter* (Schmitt 1943, pp. 16–25).

Schmitt tends to date the last two works much earlier, due to the similarities in the scenographic arrangement of the ruins[8]. However, on closer inspection, some differences can be recognised. The most striking aspect in the composition of *Ruined Monastery of Eldena near Greifswald* is the inclusion of flourishing vegetation with climbing and infesting plants, which gives a completely different interpretation of the architectural spatiality. As far as the interpretation of the painting is concerned, the inclusion of the hut with the people living and playing in the middle of the ruins still seems to give a positive meaning to the figure of ruins protecting human settlements and offering them a shelter. However, it also emphasizes a historicist reception that compares the protective aspect of medieval ruins with the dilapidation and transitory value of the dwellings of the past (Scholl 2007, p. 185).

Scholl highlights how the painter managed the representation of the spatiality of the church nave at the time he painted, both in *Ruins of Eldena near Greifswald* and in *The Eldena Abbey in Greifswald, 17 March 1836*, as well as in other depictions of Eldena. Considerations must be made regarding the presence or absence of huts and settlements in different works, as well as alterations to architectural elements; the west counter-façade window of the church may be buffered, opened or decorated, and architectural details that were originally part of the architectural space have been subsequently removed or altered (Scholl 2007, p. 186). Such a study would help us to understand how the reception of Caspar David Friedrich's paintings was influenced by the interpretation of the spatiality of the architectural spaces he designed. Therefore, a research study in this direction could provide new further information and input into the interpretation of Friedrich's depiction of spatiality.

1.4. State-of-the-Art and Related Research

There have been several other research experiences related to the 3D reconstruction of paintings and images and most of them have approached the topic from a different perspective. These several research approaches have ended up demonstrating different ways of conceiving the methodology of changing an image into a three-dimensional model. It is worth mentioning that the application of this methodology in previous research studies about this topic has been affected by the input object of the research.

In this state-of-the-art section, we are going to mention not only experiences related to the reconstruction of artworks but also approaches linked to the rectification and reconstruction of perspective images.

1.4.1. Single View Reconstruction

Among the research studies, it is of interest to mention two of them (Liebowitz et al. 1999; Wan and Yang 2014), related to two different kinds of topic with two different approaches. The first aspect of these studies involves creating 3D models from a single image. This is achieved by considering the presence of geometrical constraints and the properties of descriptive geometry to reconstruct several connections between them (Wan and Yang

2014). Each factor is addressed individually within this study. Liebowitz, Criminisi and Zimmermann's study (Liebowitz et al. 1999) utilises parallelism and orthogonality in the analysed scenes to achieve a reconstruction that does not rely on objective measurements or on the distance of the observer from the 2D representation. This study breaks down the scene reconstruction process into multiple stages, resulting in the reconstruction of single elements of the scene. To this end, their method has been applied in their research to several photographs and then to the painting *The Flagellation of Christ* by Piero della Francesca, whose spatiality has been reconstructed in 3D using this method (Liebowitz et al. 1999, pp. 5–6).

1.4.2. 3D Digital Reconstruction of Paintings

In another study, which will be discussed later, Depero's paintings, featuring imaginary urban representations, were reconstructed in a 3D digital space. The publication describes the process of three-dimensional reconstruction of the pictorial scene in a schematic manner, from the discretization phase to the texturing of the surfaces. Within this research, parametric modelling is used to render and reproduce the artist's spatial deformations within the modelling software (Cristofolini and Bernardi 2019). Studies concerning the reconstruction of architectural spatiality include the representation of existing architecture within paintings. On a similar wavelength, A. Sdegno's (Sdegno 2004) study focused on reconstructing the architectural motif of the *Chiostro del Convento della Carità*, designed by Andrea Palladio and represented in a painting by Antonio Canal (*Canaletto)*. The study compared the proportions in the painting to those of the original building designed by Palladio. The author acknowledges that the painter's altimetry differs from that of Palladio's façade. The study highlights the painter's intention to accentuate the vertical dimensions of the façade, which makes it appear more slender than the architecture of the cloister. This study analyses the creative process of Canaletto himself as he stood in front of the building. He typically used a *camera obscura* to create the perspectives, which he then transferred on paper as the underdrawing for his painting.

It could be interesting to analyse the previous experiences of reconstructing three-dimensional scenarios from single views or photographs using semi-automated and computer-based procedures. However, other types of images could not be reconstructed reliably. There is a substantial body of research that has investigated the reconstruction of three-dimensional spaces from different images of the same scene or object. This is achieved by reconstructing the position and parameters of the camera using pixel overlay, a method that has been widely used since the 1980s and subsequently rebranded as 'photogrammetry'. It has been applied in numerous industrial and research fields (see also Fraser and Brown 1986). In this case, however, we are concerned with single-view reconstruction, a topic that has also been addressed in several cases by research that has not, however, managed to provide a definitive answer to the three-dimensional reconstruction of a single view. This is because the majority of published studies have focused on the reconstruction of only certain types of images and photographs.

The first approach to mention concerning works of art is the one reported in several publications of the Engineering Department of the University of Florence (Carfagni et al. 2012; Furferi et al. 2024; Volpe et al. 2014). These publications debate the possibility of using 3D modelling for the fruition of paintings by visually impaired visitors within museum environments. In this instance, the publications address the creation of three-dimensional models for the tactile experience of artworks. The authors describe various methods for modelling the scene of the painting, including the bas-relief method, which consists of extruding the main surfaces of the representation out of the surface defining the background of the painting. In this instance, the 3D reconstruction in the modelling

software is initiated by manually extruding a "room"-type structure, which establishes a gradient and consequently assigns a value to each surface of the painting. The gradient is then employed to define a depth map, which is subsequently utilised for the extrusion of the foreground objects. Once the surfaces have been extruded with basic modelling commands, the elements of the painting can be obtained in their three-dimensionality. The metric and dimensional aspects are not considered in this case, as the focus is on the experiential and practical aspects of prototyping the work of art. From the point of view of the reconstruction of photographs or paintings, the first approaches to 3D reconstruction were made in the late 1990s, when Horry et al. (Horry et al. 1997) worked on the creation of a methodology based on modelling the work of art by segmenting it, dividing the composition into background and foreground objects. Once this difference is defined, a perspective structure is developed and a GUI linked to it, which, once the vanishing point has been defined, allows the 3D reconstruction of the background surfaces through the creation of a spider mesh. In the same way, the system developed in this publication enables the modelling of the foreground objects by segmenting them with respect to the background (which is modelled according to the "spidery mesh"). By modelling them through simple geometric figures, the positions in space are defined by the relationship of perpendicularity with the surfaces of the "room" identified by the "spidery mesh". In this case, the surfaces of the foreground objects are organised according to a hierarchy based on the perpendicularity between the different surfaces. The methodology developed for this publication, in conjunction with the study by Hoiem et al. (Hoiem et al. 2005), represents a pioneering approach to the 3D reconstruction of paintings. It is based on the objective of enabling the creation of animations of the depicted scene—providing different views of the composition. However, this type of study was subject to certain limitations, including the fact that the starting representation had to be a perspective with a single vanishing point or at least with an orientation of the composition in a very clear direction.

Another noteworthy contribution is the study by Hoiem et al., which presents a method for the 3D reconstruction of photographs in the form of pop-up books. This is achieved through the development of a segmentation system, which initially classifies the different portions of the image using a statistical model that assigns different labels to the different segments. A statistical model structured in this way enables the automatic definition of the position of each segment of the image under consideration. This is achieved by defining the different positions with labels, which are the classes 'floor', 'ceiling', 'walls' and 'background'. The model is trained with such labels so that it can subsequently attribute different sections of an image that will be analysed through the process. This methodology is defined by the authors themselves as being linked to a much more statistical than geometric approach, which makes the use of the statistical model central to the automation of this process. This means that this methodology is not applicable to every type of image.

1.4.3. Brief Description of Studies on Neural Networks for 3D Reconstruction of 2D Items

Other noteworthy contributions pertain to the reconstruction of individual elements of photographs or representations through the utilisation of models and algorithms for the extraction of the figures represented in the image (see also Kanazawa et al. 2016). There are several published studies in this field, which represents one of the most flourishing areas of research in the field of 3D reconstruction from single images. A plethora of studies have been conducted in this field over the past decade, resulting in a variety of 3D reconstruction solutions for individual elements. One notable study is that of Saito et al. (Saito et al. 2020), which presents a 3D reconstruction system in obj. format for human figures derived from high-resolution photos. Furthermore, the tool is capable of reconstructing all those

parts that are not visible in the reference image, providing the user a model of the figure represented in the image through the use of training modes within the function.

2. Results

2.1. The Reconstruction of the "Abbey in the Oakwood" and the Reconstruction Scenarios

This section will examine the application of the reconstructive methodology to one of Friedrich's most iconic paintings, *Abbey in the Oakwood* (Figure 1). The main points of the methodology will be addressed, with a focus on the results and limitations of its application. In particular, the modelling of the nave of the church depicted in the aforementioned painting will be analysed.



Figure 1. Caspar David Friedrich, *Abbey in the Oakwood*, 1809/10, 110.4 × 171 cm, oil on canvas, Inv. Nr.: NG 8/85, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Andres Kilger. Public Domain Mark 1.0[9].

The results of the reconstruction of the perspective structure of the pillars of the church depicted by Friedrich according to the methods described above lead us to study different scenarios in 3D digital space. This analytical method allows us to understand Friedrich's perspective representation and how the positioning of the point of view can influence the architectural spatiality in the pictorial representation.

It is crucial to highlight that the three principal assumptions underlying the reconstruction are as follows:

- The consistency of the 3D reconstruction of the columns with the projection of their apparent contours.
- The consistency of the modelling process with the vanishing lines identified by the sequence of columns.
- By tracing the same vanishing lines, it is possible to identify several slightly shifted points of view that are specific to certain elements of the composition. One of the most significant assumptions in the analysis of this painting by Friedrich pertains to the structure of the vanishing points. There are multiple such points, each referring to a distinct part of the painting. Consequently, we have elected to concentrate our analysis on the spatial aspects of the nave of the church designed by Friedrich in the paintings, given that all the pillars depicted in these paintings possess the same vanishing points (one for each painting).
- Another fundamental assumption pertains to the manner in which the results of each reconstruction scenario for each painting will be presented. It is crucial to emphasise

that, in the absence of an objective measure of the painting's representation, the most reliable value to rely on is the ratio between the individual columns and the distance between them. As the dimensions are affected by the distance of the observer from the plane of the painting, namely, they are not fixed but change when switching between scenarios, the dimensions obtained from the reconstruction scenarios of the nave in the painting are, in some cases, not comparable with those of a Gothic church (in this case, the Abbey of Eldena).

In relation to the aforementioned assumptions, it is important to note that the following article will undertake a proportional comparison between the Church of Eldena and the reconstruction of the central nave depicted by Friedrich. However, this comparison will only be made in the case that one of the dimensions of the reconstructed nave is equal to one of the dimensions of the 'real' Church of Eldena (for further details, please see pp. 17–20). The objective of the proposed study is to analyse the compositional pattern revealed by the reconstruction of the nave of the church depicted by Friedrich through the study of ratio values. In certain instances, these values will be compared with those of the reconstruction of the architectural survey of Eldena presented by Balthasar in 1857. This will facilitate an understanding of the relationship between the depicted spatiality and its reference, as well as the extent to which the painter adhered to the reference of Eldena Abbey.

The position of the observer in relation to the picture plane affects the dimensions of the depicted elements by Friedrich in three-dimensional space. As there is no objective measure in the representation, a "rail" can be defined on which the observer can be positioned at different distances from the picture. The position of the observer in three-dimensional space is given by the reconstruction of the vanishing lines (Figure 2).

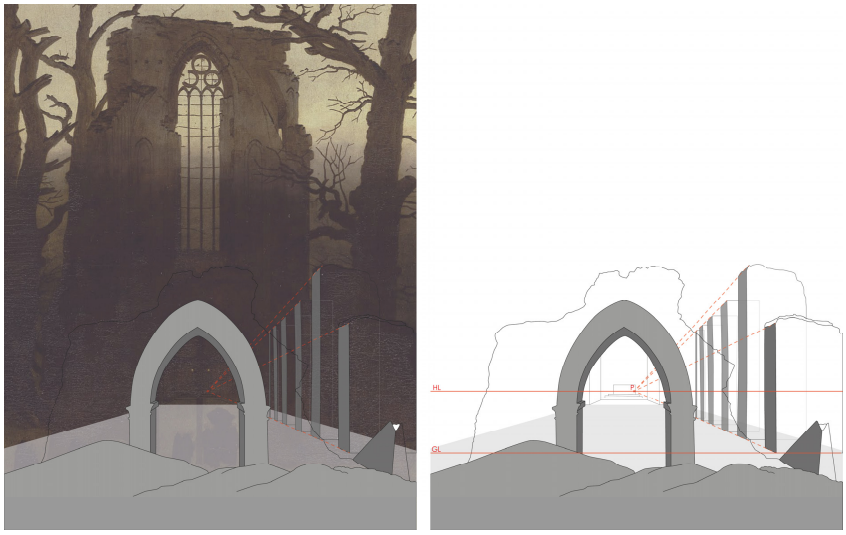


Figure 2. Schematic view with relevant lines only visible in the underdrawing (Mösl 2020). Determination of the vanishing point of the nave of the church in the painting *Abbey in the Oakwood* by Caspar David Friedrich. In the background: Caspar David Friedrich, *Abbey in the Oakwood*, 1809/10, 110.4 × 171 cm, oil on canvas, Inv. Nr.: NG 8/85, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Andres Kilger. Public Domain Mark 1.0 (Ibid).

The inability to provide an objective measurement does not preclude the possibility of understanding, from a proportional perspective, how Caspar David Friedrich interpreted the arrangement of the architectural space of the nave of the church he depicted.

The pipeline used in the three analysed artworks presented in this study in order to reconstruct the main nave of the church designed by Friedrich is as follows (see Figure 3):

1. Vanishing point detection (Figure 2);

2. Definition of the observer's position and distance from the scene (Figure 3a);
3. Definition of the outline (apparent contour) of the pillar in the foreground (Figure 3b);
4. The outline is then extruded until it reaches the outline that defines the back of the pillar itself (Figure 3c);
5. The contour of the following pillar on the picture plane is then defined (Figure 3e,f);
6. The outline is aligned with the outline of the first column (Figure 3g);
7. Shift of the outline in depth to the corresponding pillar's position (Figure 3h,i);
8. The outline is scaled and adapted to align with the apparent contour (Figure 3j);
9. Like point 4 (Figure 3k,l);
10. The procedure is then applied to the remaining pillars of the church, reconstructing them in accordance with the aforementioned methodology (Figure 3m).



Figure 3. Pipeline for the reconstruction of the nave of the church represented by Friedrich in *Abbey in the Oakwood*, *Ruined Monastery of Eldena near Greifswald* and *The Eldena Abbey in Greifswald, 17 March 1836*. In the background: Caspar David Friedrich, *Abbey in the Oakwood*, 1809/10, 110.4 × 171 cm, oil on canvas, Inv. Nr.: NG 8/85, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Andres Kilger. Public Domain Mark 1.0 (Ibid).

In order to analyse the perspectival construction of the architectural space defined by Friedrich, different scenarios were identified in order to understand how the positioning of the observer affects the composition of the elements of the painting in three-dimensional space. Furthermore, it would be interesting to understand whether there is a fixed proportionality between the dimensions in relation to the variation of the scenarios and thus to the movement of the observer in front of the representation. This recognition provides insight into the painter's approach to perspective framework. The selection of viewpoint can be regarded as a form of degree of freedom and Friedrich's representation allows for the exploration of diverse spatial configurations within his artistic oeuvre.

In order to ascertain the effect of distance on the perceived size of the representation, observers have been positioned at varying distances from the picture plane.

2.1.1. First Scenario: Distance of the Observer from the Picture Plane of 22.58 m

In the initial scenario, the observer was situated at a distance of 22.58 m from the plane of representation. In this instance, the columns appear to be considerably elongated in depth and do not align with the proportions depicted in the painting, although they do correspond with the apparent contour outlines. The principal analysis in this case concerns the relationship between the "solids" and the "voids," with the pillars of the church designated as "solids" and the intercolumniations as "voids". In light of the aforementioned limitations, it is necessary to analyse the ratios between the reconstructed objects as a compositional benchmark. This will enable an understanding of how the variation in the positioning of the observer affects the modelling, and whether these ratios remain consistent when switching from one scenario to another. The scheme of the first reconstruction scenario can be seen in Figure 4.

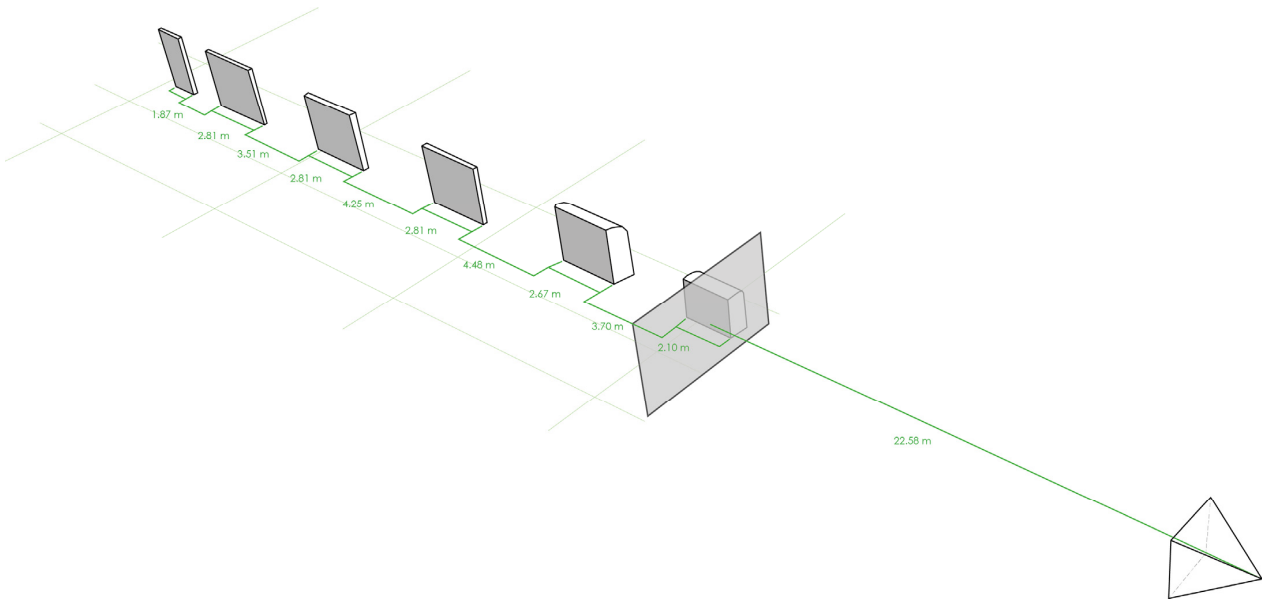


Figure 4. First scenario. the observer is situated at a distance of 22.58 m from the picture plane.

In all the analysed cases, the columns will be numbered from the closest to the picture plane to the furthest. The same reasoning will be applied to the gaps between one column and the other. Table 1 describes the ratio values of the first scenario.

Table 1. First Scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	3.70	2.10	1.76
2	4.48	2.67	1.68
3	4.25	2.81	1.51
4	3.51	2.81	1.25
5	1.87	2.81	0.67

To assess the reliability of the reconstruction methodology, we decided to summarise some results in key points:

- In the case of the third, fourth, and fifth pillars, the same sizes were used (2.81 m) as it was noted that by copying the columns, they were able to respect the outlines determined by the apparent contour and the vanishing lines. This aspect defines the fact that, in the portion of the painting nearer to the façade of the church, Friedrich was able to respect a certain gradualness in the perspective representation of the pillars.
- The total depth from the picture plane to the last pillar is 31.03 m; this dimension can be compared both with the real measurement of the nave of the church and with the ones of the following scenarios, since this dimension gives us an idea of the difference in depth of the whole reconstructed scene when the point of view is shifted.
- With regard to the structure of the columns, it is possible to point out with regard to the first two columns (since it is possible to identify the two dimensions) that the proportions of the column on the y-axis seem to develop more in depth than in width (x-axis, parallel to the picture plane). Of course, this is also due to the distance of the point of view from the plane of the image, and in the analysed scenario, the shape of the pillar seems much more similar to the proportions of a partition wall.
- In terms of numerical dimensions, it is important to note that the ratio of intercolumnar to pillar thickness decreases with depth. This is not due to a proportional decrease in the same sequence of column and intercolumn lengths, but rather because the size of each successive column and intercolumn effectively defines a decrease in this ratio. In the case of columns 1 and 2, column 1 is shallower than column 2, but the successive intervals of empty space are proportionally larger. Therefore, there is not always a progressive increase in column size and a decrease in column spacing. However, the ratio tends to decrease as we approach the vanishing point.
- The decrease in this ratio indicates a 'densification' of objects (in this case pillars) in the representation of three-dimensional space as one moves away from the observer. The dimensions of the columns remain fairly similar, but the distances between them steadily decrease as one approaches the vanishing point. This natural evolution results in a gradual 'densification' of the architectural space. This can also be observed in the ratio of intervals to columns, which decreases from a maximum of 1.76 to a minimum of 0.67.

This means that the dimensions of the pillars and intercolumniations reversed as we moved deeper into the space.

2.1.2. Second Scenario: Distance of the Observer from the Picture Plane of 13.20 m

In this case, the point of view has been moved closer to the image at a distance of 13.20 m. In this case, the results are slightly different. Firstly, the development of depth in 3D space is less pronounced, since we have a dimension perpendicular to the plane of the picture of 18.60 m. The following Figure 5 represents the second reconstruction scenario.

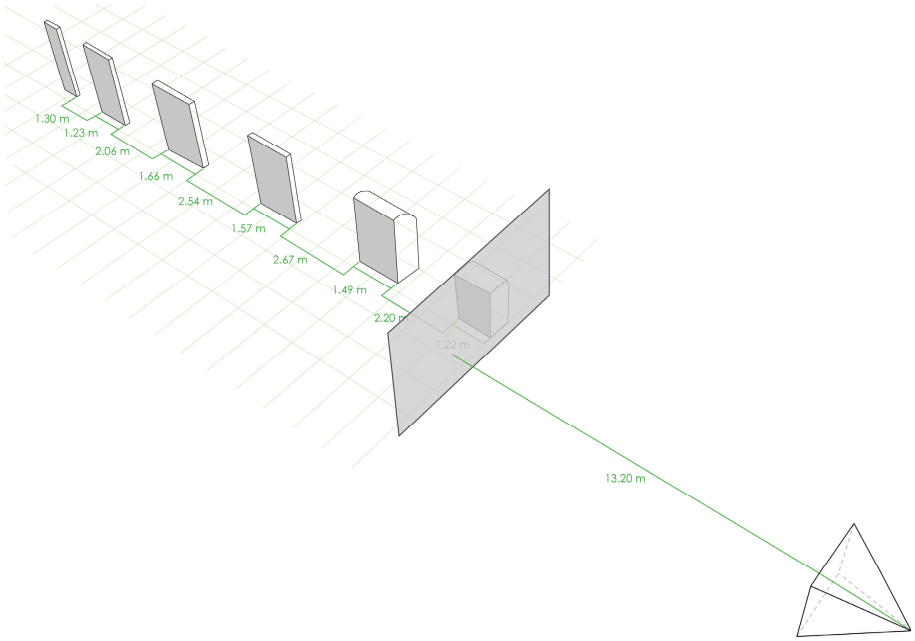


Figure 5. Second scenario: distance of 13.20 m from the picture plane.

The order of the gaps and columns is the same as in the previous scenario. In Table 2, the values of the second reconstruction scenario are described.

Table 2. Second Scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	2.20	1.22	1.80
2	2.67	1.49	1.79
3	2.54	1.57	1.62
4	2.06	1.66	1.24
5	1.29	1.23	1.05

This second scenario brings with it a number of considerations:

- Once again, we see a pillar structure that is mainly developed in depth compared with the direction that is parallel to the picture plane.
- The dimensions of the columns are much more irregular and change unevenly. On the other hand, the spaces between the columns decrease in a regular way, except for the first column and the first gap.
- In a similar way to the first scenario, the 'densification' of the representation in three-dimensional space can be detected. Indeed, the ratio between the two quantities tends to decrease as one moves along the y-axis. However, in this case, unlike in the previous scenario, the ratio always remains in favour of the spaces between one column and the other, and therefore does not decrease below 1.
- In this scenario, unlike the first one, there is no regularity in the size of the columns, but, on the other hand, there is more regularity in the size of the gaps between one column and another.

The reason for creating these scenarios is also to understand whether there are similarities or proportionality in the dimensions created by moving the observer closer or further away from the picture plane. Here, it is important to mention a crucial aspect of this study; we must consider a graphical error related to the thickness of the lines of the drawing, which has a decisive influence on the dimensioning of the architectural elements. This error is due to the choices made by the modeller in interpreting the drawing of Friedrich's

painting. An orderly comparison of the proportions of the two scenarios leads us to one reflection.

From the first to the fourth pillar, we can see a certain similarity in the values which leads us to recognise a certain proportionality of the dimensions in the passage from one point of view to the other. In fact, the dimensions maintain a consistent proportionality with the distance of the point of view from the picture plane. However, as far as the fifth pillar is concerned, we notice a remarkable difference between the first and the second scenario; we must consider that the main factor to be found is a much more relevant "densification" in the first scenario. This allows us to understand how the greater distance of the point of view from the picture creates an "accelerated" view compared with the shorter distance, which defines a more balanced relationship between the volumes (and voids) in depth.

2.1.3. Third Scenario: Reconstruction of the Eldena Monastery

In order to analyse the way in which Friedrich synthesised the spatiality of the monastery of Eldena (Figure 6), a 3D reconstruction of the church was carried out according to cartographic, photographic, bibliographic and pictorial sources (Apollonio et al. 2021; Hacker 1953; Kloer 1929; Lissok 1997; Pyl 1880; Schmitt 1943) that documented the state of the monastery at the time when Friedrich himself was involved in the representation of the church. Also decisive were the sketches made by Friedrich on the various occasions when he decided to represent the ruins of Eldena (see also Grummt 2011). The following Table 3 shows the values related to the 3D reconstruction through heterogeneous sources.



Figure 6. The ruins of Eldena near Greifswald today (Photo: Karge 2024).

Table 3. Third scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	2.82	1.60	1.76
2	2.91	1.53	1.90
3	2.88	1.57	1.83
4	2.88	1.58	1.82
5	2.87	1.55	1.85

In this case, the first six pillars of the structure have been taken into account, leaving out the last pillar and the last span, as in the other scenarios. Of course, in this case, the ratio between the pillar and the intercolumniation is much more regular, and this is quite normal for the structure of a church with an alternation of supports, such as the Church of Mary of the Monastery of Eldena. The relationship between the reconstructed scene and the "real" structure of the church of Eldena gives us a clear pattern of how the painter manipulated the three-dimensional space in order to deliver his representation. In the following Figure 7, the graph describes the trend of the pillar depth for the five reconstruction scenarios. Figure 8 describes the trend related to the dimensions of the intercolumnar spaces.

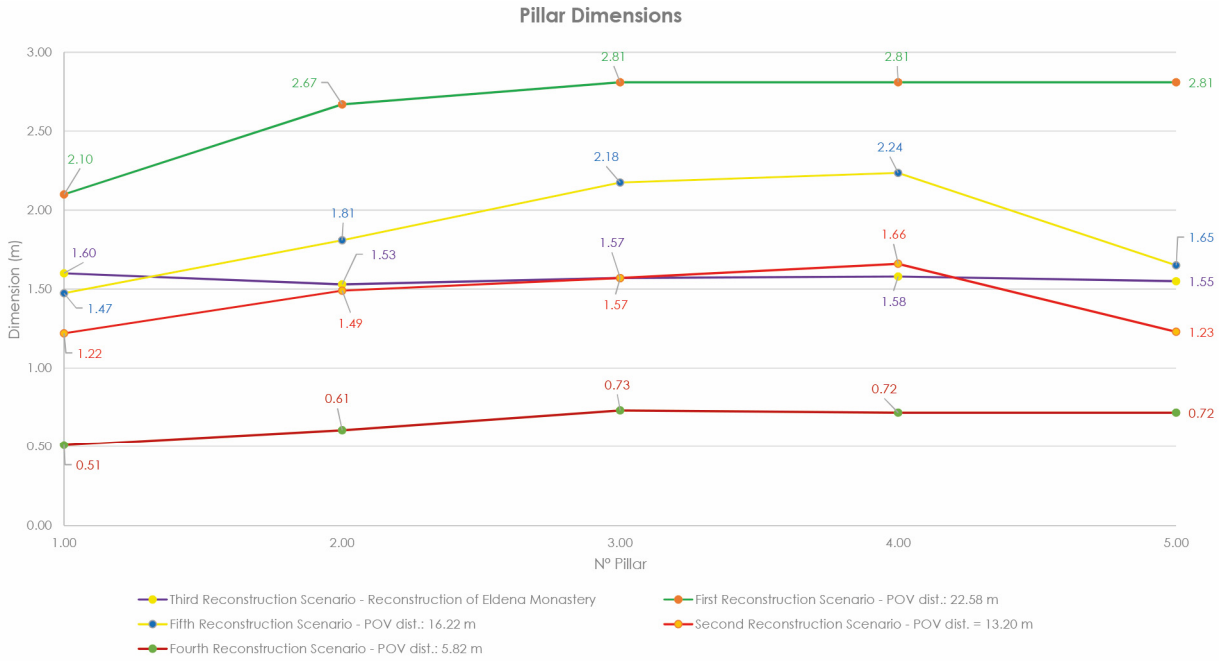


Figure 7. Comparison of the dimensions of the pillars in the different reconstruction scenarios. In the 3 described reconstruction scenarios and the additional 2 scenarios of the spatiality of the nave defined by Friedrich, it is possible to see that the dimensions of the pillars are irregular within the intervals considered. It is worth mentioning that the value of the width of each column must be compared with the width of the corresponding intercolumnar space in order to detect the "densification" in the representation of the nave of the church in *Abbey in the Oakwood*.

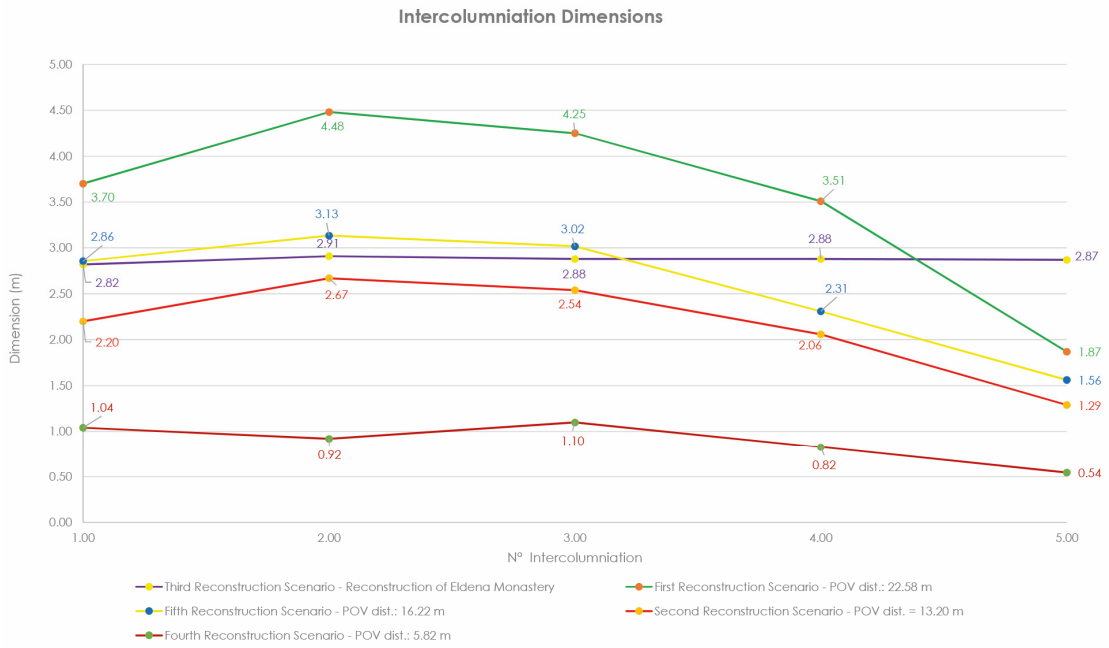


Figure 8. The comparison between the dimensions of the intercolumniation in the different reconstruction scenarios. In the 3 described reconstruction scenarios and the additional 2 scenarios of the spatiality of the church defined by Friedrich, it is possible to recognize that the intercolumniation are decreasing steadily and that this is the main reason for the "densificated" spatial patterns of the reconstruction.

Let us make a few considerations regarding this last scenario and the two previous ones:

- While in the case of the first scenario it was not possible to define a comparable case to the real one, in the second scenario, if we consider the third ratio, a similarity can be discerned with regard to column thickness (1.57 m—second scenario and 1.57 m 'real' scenario) and intercolumniation width (2.54 m—second scenario and 2.87 m), although in this case we have a difference of approximately 30 cm between the two values, which is a considerable difference.
- Highlighting the ratios in the case considered, we have two values: 1.62 (second scenario) and 1.84 (Eldena reconstruction). We have a difference of 0.22 between the two ratios, and if we consider the difference between the ratios of the other pillars, especially those closest to the frame, this quantity is remarkable, since in the second scenario, the difference between the ratios of the first pillar (1.81), second pillar (1.79), and third pillar (1.62) is progressively 0.02 (first–second) and 0.17 (second–third). This shows that a difference between ratios such as the one highlighted at the beginning is still very significant, and therefore the proportional difference between the two different scenarios is also very high.
- By comparing with Eldena's reconstruction, it is possible to trigger not only the metric difference between the two scenarios, but above all a particular proportional difference that shows how the painter defined the pictorial space without a rigid perspective structure. Although he maintained a certain regularity in the size of the pillars in the depth, the distance between the pillars appears to have progressively decreased as one approaches the vanishing point.
- Another very interesting aspect is also the total dimension in depth of the second reconstructed scenario (coloured in red in Figures 9 and 10) compared with the length of the nave in the analysis (of the third scenario—purple in the images and graphs). The total length of the considered part of the nave (in the third scenario—purple in

the Figures 9 and 10) is 23.69 m, while in the second scenario (in which the depth of the third pillar coincides with the third pillar of the church of Eldena), we have a dimension of 18.60 m. This dimension makes us even more aware of how the space created by Friedrich was "compressed" in order to emphasise the perspective effect of the representation. Figures 9 and 10 summarise the spatial arrangement of the nave of the church of Eldena and the two reconstruction scenarios described above. In Figure 11 we can see the comparison between the partial reconstruction of the painting in the first scenario described above and the painting by the Greifswald artist.

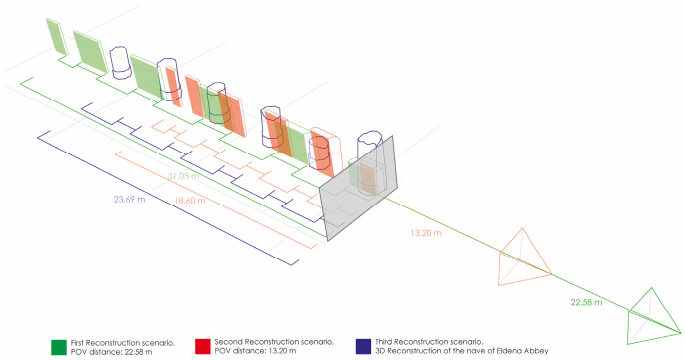


Figure 9. 3D scheme that describes graphically the spatial comparison between the two reconstruction scenarios and the spatiality of the central aisle of the Eldena Abbey.



Figure 10. Overlay of the 3 reconstructed scenarios in the perspective view of the observer 22.58 m away from the painted surface. In the background: Caspar David Friedrich, *Abbey in the Oakwood*, 1809/10, 110.4 × 171 cm, oil on canvas, Inv. Nr.: NG 8/85, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Andres Kilger. Public Domain Mark 1.0 (Ibid).



Figure 11. Render of the reconstruction of a part of the painting *Abbey in the Oakwood* with superposition of the painting itself. This image follows the first reconstruction scenario with the POV at a distance of 22.58 m from the picture plane. In the background: Caspar David Friedrich, *Abbey in the Oakwood*, 1809/10, 110.4 × 171 cm, oil on canvas, Inv. Nr.: NG 8/85, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Andres Kilger. Public Domain Mark 1.0 (Ibid).

The possibility of analysing the spatial arrangement created by Friedrich by means of 3D modelling led us to understand that Friedrich's space is characterised by a strong perspective characterisation but avoiding a regular geometric configuration of spatiality.

One key finding should also be highlighted.

Despite the lack of a regular geometric structure, Friedrich's way of representing space in perspective and the progressive 'densification' of the representation seems to be a conscious choice by the artist. This can be seen in the author's desire to create a recognisably perspectival space; its perception would only be possible with the representation of a significant number of columns, which would increase the sense of depth of the space. For this reason, the greater regularity of the perspectival representation close to the picture plane is lacking in the pillars in the background, where the space between the pillars becomes progressively smaller. In this way, there are six pillars in perspective, which would have been fewer if the church had been depicted with the measurements of the church of Eldena. This would also have resulted in a less emphasised perspective in comparison with the one created by Friedrich. Moreover, on a compositional level, this formal choice seems to emphasise the monks' path through the area enclosed by the ruins of the church to the altar framed by the western façade.

In Figure 12, it is possible to identify a progressive decrease in the values of the ratio, as we are progressing towards the vanishing point of the depicted scene.

This section of the study describes how this reconstruction methodology can be deployed to analyse the spatiality of the painting *Abbey in the Oakwood* by Caspar David Friedrich. It also demonstrates how insights on the spatiality developed by Friedrich can

be gained through such methodology. To prove the reliability of this methodology and gain further insights, it was applied to other paintings that portrayed Eldena.



Figure 12. The comparison between the reconstruction scenarios. In the 3 described reconstruction scenarios and the additional 2 scenarios, by analysing the spatiality of the church defined by Friedrich, it is possible to identify a constant decrease in the value of the ratio. For this reason, it is possible to define the spatial pattern of the "densification".

2.2. Application of the Methodology to Another Painting: Ruined Monastery of Eldena near Greifswald (1825)

In order to understand whether the use of the methodology applied to *Abbey in the Oakwood* could be useful for enlarging the spatial analysis of Friedrich's depiction of the architectural motif, it was decided to extend the analysis to a second painting with similar characteristics to this first example but with a different spatial structure. It was decided to analyse the painting *Ruined Monastery of Eldena near Greifswald* (Figure 13), in which the painter this time clearly depicts a reproduction of the ruins of Eldena and, in particular, the nave of the church. In this case, it is worth emphasising the name of the work, which differs from the previously analysed one in a clear manner, although the main architectural reference remains the same.

In this case, the painting is referred to as *Abbey in the Oakwood* as if the abbey in question were any Gothic Abbey and not precisely the church of Eldena, and this is confirmed by the large metric differences shown above. Furthermore, it should be noted that between Friedrich's depiction and the ruins of the monastery of Eldena, considerable portions of the building have not been represented. The painter removed, added and modified portions of the church to his will, creating a new architectural organism based on the Greifswald monastery[10] (see Scholl 2007, p. 182). On the other hand, the painting selected for our second analysis appears to be an almost faithful reproduction of a state of the Eldena ruins at a specific historical period. In fact, one element that stands out very clearly is the presence of the huts leaning against the supports of the nave of the church. Their presence is also documented by sources that have reconstructed the maintenance of the ruins over the centuries: in particular, these writings specify the fact that the decision to remove these huts was one of strong reluctance by the local authorities, as was generally the case for the settlement of the entire archaeological area of Eldena[11] (Lissok 1997, p. 85). From the first measurement using the same methodology, we recognise a much more harmonious regularity of the architectural space and of the relationships between volumes than those

reconstructed in *Abbey in the Oakwood*. In fact, in this case, we recognise a similarity between an ideal religious space and Friedrich's representation. In this case, we can consider the naming of the work as an element that seems to identify a degree of abstraction by the artist with respect to the reference object represented. This aspect is not verified through metric or quantitative similarity (although in the second work the ratio value is more regular), but considering the quantity of architectural elements represented with respect to Eldena's church, it is easy to understand the reason for this difference in naming.



Figure 13. Caspar David Friedrich, *Ruined Monastery of Eldena near Greifswald*, 1824/25, oil on canvas, 49 × 35 cm, Inv. No: A II 574, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Jörg P. Anders, Public Domain Mark 1.0[12].

As far as the analysis of the painting is concerned, we proceeded with the same methodology, always considering that there were no metric inputs that would allow a scientific reconstruction of the painting's space, even considering that the theme of the representation is the ruins of Eldena, which in this case, allows for a precise comparison between the Critical Digital Model[13] (Apollonio et al. 2021, pp. 5–6) and the reconstruction of the painting's three-dimensional scenario. This will make it possible to understand whether, at least at the proportional level, the German painter tried to faithfully reproduce the spatiality of the church. If we consider the perspective reconstruction of the representation, we must consider how the painter in this case decided to represent the pillars of the church. Indeed, in this case, it is more complicated to reconstruct with certainty the construction lines of the perspective view depicted by Friedrich. Some limitations should be noted, which lead to some important approximations in the analysis:

- The vanishing lines of the pillar bases are not always visible within the representation, which is why they have all been assumed to be aligned in the same direction and therefore vanish to a single point.
- In contrast to the first representation in which the elements represented were depicted in a stylised manner, in this case, there is greater detail in certain compositional elements that have been simplified into simple shapes such as box-like shapes that describe the three-dimensional appearance but not their formal composition.

This last solution in particular helps us to understand the dimensions of the objects more than their formal arrangement, since it is one of the main features that allows us to define the proportional relationship between the depicted objects.

2.2.1. First Reconstruction Scenario and Comparison with the First Scenario of Abbey in the Oakwood

The first step in the spatial reconstruction of the painting '*Ruined Monastery of Eldena near Greifswald*' is the recognition of vanishing points relative to the different portions of the painting. First of all, we are faced with a perspective structure where the observer is not in the central area of the painting, but rather shifted towards the left side of the composition (Figure 14).

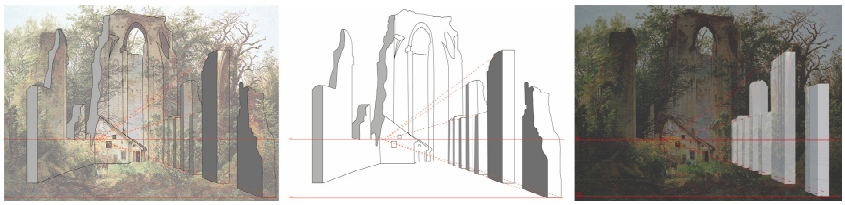


Figure 14. Detection of the vanishing point of the right side of the nave of the church represented in the painting *Ruined Monastery of Eldena near Greifswald* by Caspar David Friedrich. In the background: Caspar David Friedrich, *Ruined Monastery of Eldena near Greifswald*, 1824/25, oil on canvas, 49 × 35 cm, Inv. No: A II 574, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Jörg P. Anders, Public Domain Mark 1.0[14].

This is also understandable from the view of the nave, which allows a more detailed and complete observation of the row of pillars on the right side of the painting. This compositional choice makes it easier to apply the reconstructive methodology and to compare with the Eldena church modelled according to heterogeneous sources. The analysis will focus on the row of pillars relative to the right section of the painting, which would be the same as that analysed for *Abbey in the Oakwood*. This allows for a cross comparison with the spatiality of the two paintings in order to understand the differences between the two representations. Once the vanishing point had been located off-centre from the structure of the painting, it was positioned at a distance of 17.70 m to create the first reconstructive scenario of this work by Friedrich. Figure 15 describes the 3D view of the first reconstruction scenario. It is possible to analyse the ratio values in Table 4.

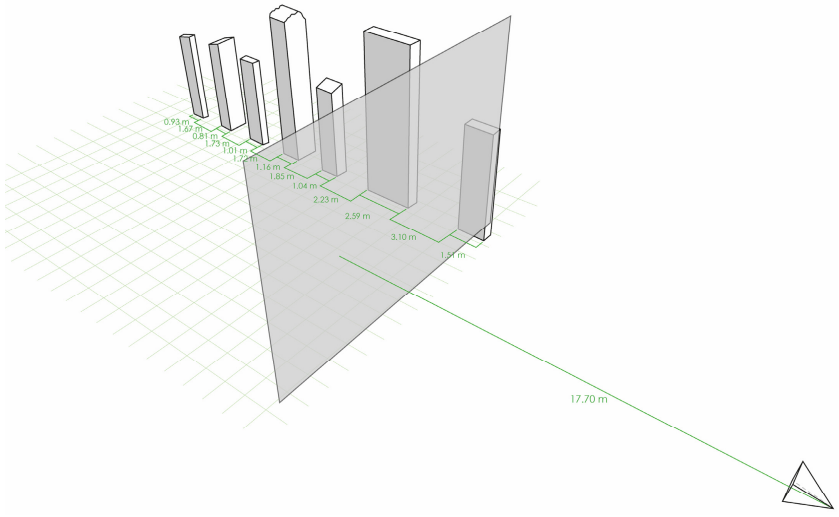


Figure 15. Scheme of the first 3D reconstruction scenario—distance of 17.70 m from the picture plane.

Table 4. First Scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	3.10	1.51	2.05
2	2.23	2.59	0.86
3	1.85	1.04	1.78
4	1.72	1.16	1.48
5	1.73	1.01	1.71
6	1.67	0.81	2.06

The depth of the whole aisle in this reconstructed scenario is 20.42 m. Some details must be considered concerning the spatiality of the church and the elements represented since, in the painting *Abbey in Oakwood*, the represented spatiality does not seem similar to the one of the nave of the church depicted by Friedrich in *Ruined Monastery of Eldena near Greifswald* (1925) as we can see from the data of the scenario. Indeed,

- In the case of the painting *Ruined Monastery of Eldena near Greifswald*, there is a representation not only of the central nave but also of portions of the span in front of the crossing of the church. This is noticeable by the difference in the decorative arrangement and detail of the columns. It can also be noticed if we measure the ratio values.
- It should also be noted that the geometry of the pillars in some cases echoes that of Eldena's church as their cross-section is hexagonal. This detail is very interesting as in the painting *Abbey in the Oakwood*, the definition of the pillars is quadrangular, much simplified in comparison with Eldena's reference.

The values of the ratio, the intercolumniation and the pillars emphasise a substantial difference from the first scenarios of *Abbey in the Oakwood*. First of all, we can see that, in this case, the number of columns represented is greater than in the previously analysed painting, and therefore the number of ratio values are also higher. However, it should be taken into account that the first intercolumnar arrangement cannot be evaluated, since it is an exception in terms of the spatiality of the nave and therefore cannot follow a proportional coherence with the rest of the composition.

Some clarifications must be made regarding the dimensions of the represented elements in this first scenario:

- The dimensions of the pillars appear to be very different from each other and even the variation in their measurements does not seem to give an indication of homogeneous reasoning. The values are only comparable in the third, fourth, and fifth spans. What can be seen is a significant decrease in this value in the last intervals up to the sixth where the dimensions of the pillars decrease abruptly.
- The size of the intercolumniations also decrease progressively, although their size remains almost the same from the third to the sixth span.
- The value of the ratio between the different intercolumniations is significantly different, emphasising the important difference between the intervals of the composition. In fact, it is possible to identify a certain irregularity in the spatiality of the church that does not follow a rigid proportional pattern.

Consequently, at least for the analysed scenario, we have a more balanced structure of the architectural space with regard to the comparison between solids (pillars) and voids (intercolumniations), which, in the progression in depth, does not have a precise rule from a proportional point of view. It is pivotal to emphasise the progressive decrease in intercolumniations, which this time are not also supported by an increase in the depth of

the columns. This defines a rather different spatiality compared with *Abbey in the Oakwood* where there is a "densification" of the space and a progressive approach of the pillars.

In conclusion, at least for the analysed scenario, the only element of similarity between the two reconstructions of the paintings is the progressive decrease in the nine intercolumnar spaces. In this case, this does not lead to a dimensional prevalence of the pillars, which in turn decrease and therefore do not give rise to a "densification" of the spatiality.

These considerations can be summarised in the following Figures 16–18, which show the differences between the sizes of the intercolumniations and pillars in three different scenarios (respectively, Reconstruction of the Monastery of Eldena, first reconstruction scenario of the *Ruined Monastery of Eldena near Greifswald* and first reconstruction scenario of the *Abbey in the Oakwood* with a POV distance of 22.58 m from the picture plane).

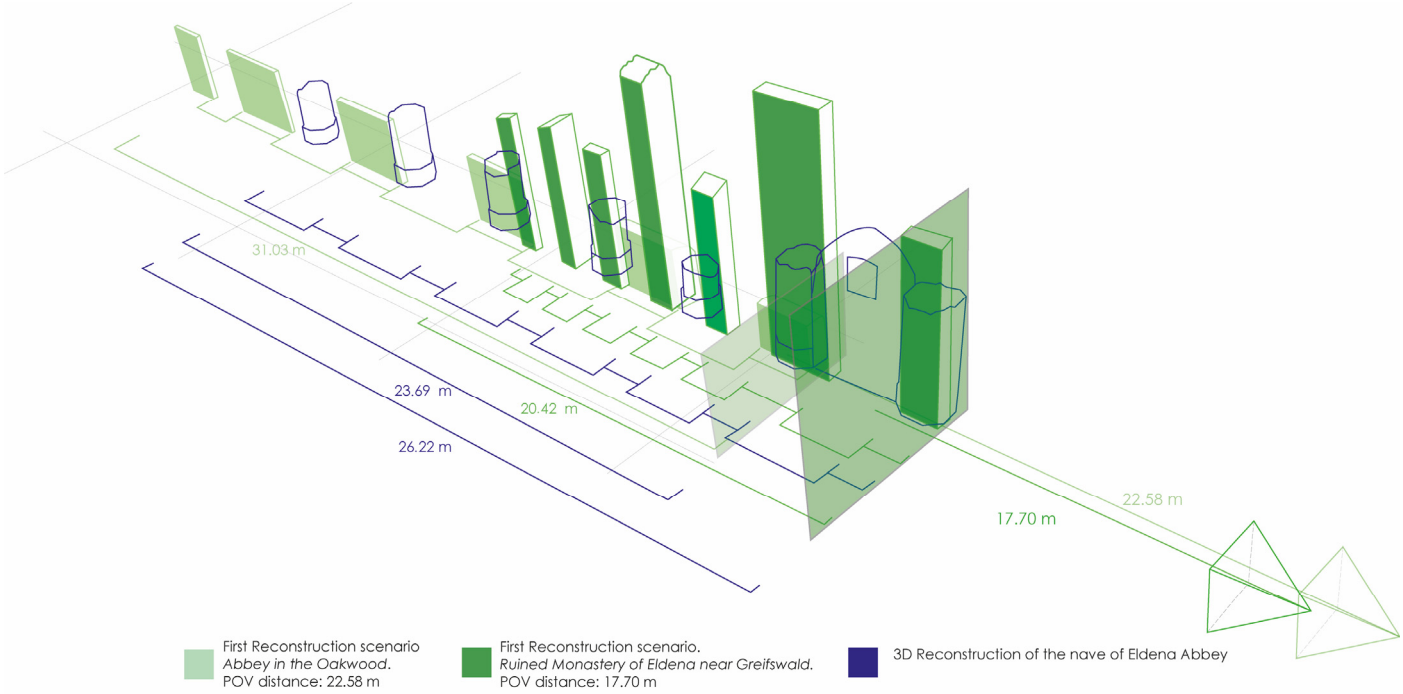


Figure 16. Comparison between the two "first" reconstruction scenarios of *Ruined Monastery of Eldena near Greifswald* and *Abbey in the Oakwood* with the reconstruction of the church of Eldena Abbey.

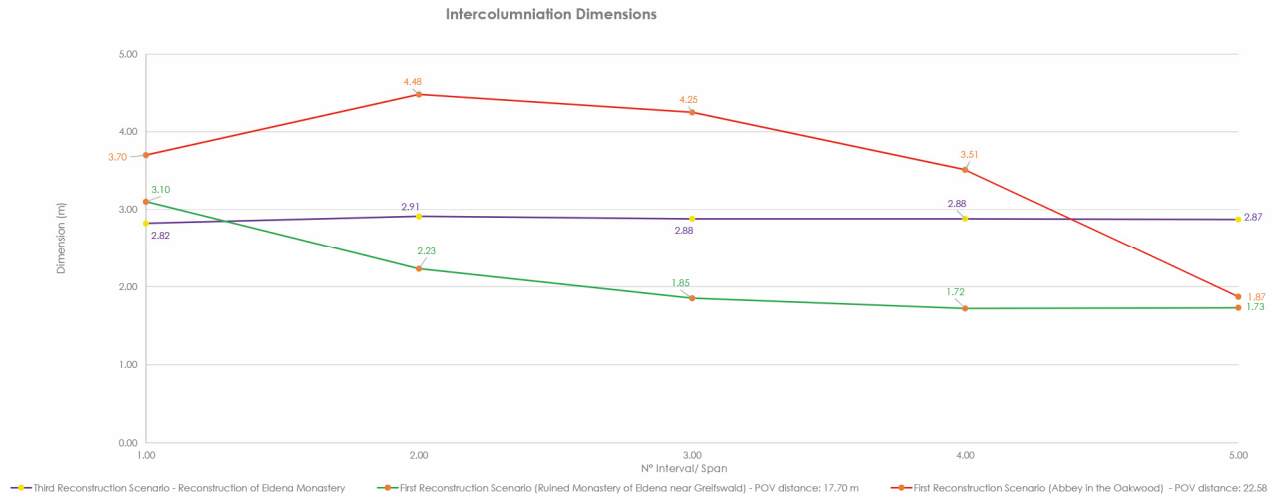


Figure 17. Intercolumnar dimensions for the different reconstructive scenarios. It should be emphasised that the trend in the intercolumnar dimensions for the reconstructive scenarios of Friedrich's representations tends to decrease in both cases, although with different trends.



Figure 18. The size of the pillars in the different reconstruction scenarios helps us to understand how the spatiality in the case of *Abbey in the Oakwood* and *Ruined Monastery of Eldena near Greifswald* is quite different. In the first image, we have an increase in the size of the columns, and in the second, we have a sudden decrease in the size of the columns, which then remain fairly stable in size, making the spatiality of the nave more balanced than that of the church represented in *Abbey in the Oakwood*.

2.2.2. Second Scenario Distance of the Observer from the Picture Plane of 6.52 m

If we consider the possibility of constructing a new scenario in order to deepen the spatial structure of Friedrich's representation, we can test it by positioning the viewpoint at 6.52 m from the picture plane and see if any proportional compositional patterns are repeated. Figure 19 describes the second reconstruction scenario. It is important to note that this scenario (as well as others previously studied) has dimensions that are not comparable to the actual dimensions of a Gothic church such as Eldena Abbey. This situation is due to the proximity of the observer to the image plane, which, in the absence of objective measurements on which to base the reconstruction, causes objects to "squeeze" onto the image plane. In addition to this geometric motivation, it must also be taken into account that the representations analysed are paintings that, in some cases (such as the *Abbey in the Oakwood* previously analysed), were designed and executed over a very long period of time and were therefore not executed on site, and in this case it is possible that there is a very large discrepancy at the metrical level in relation to the spatiality of the reference church. The results obtained from this type of scenario must be interpreted in terms of the value of the ratio that, beyond the dimensions of the reconstructed objects, provides an answer to the question of how the author translated the proportions of Eldena's nave onto canvas. In this case, therefore, it is necessary to consider the relationship between these dimensions and how they can be compared with those of the church of Eldena. All this is in order to understand how the painter reworked the spatiality of the nave of the Eldena church in his painting in comparison with that of the Greifswald church.

In this second scenario, the depth of the reconstructed aisle is 7.67 m. As can be seen from this new scenario and the results obtained in this case, it is very difficult to define a structure of spatial composition that identifies a specific rhythm of composition of "solids" and "voids". In addition, there is the problem of the detail of the represented elements, which clearly describes the architectural design, but at the same time complicates the definition of the contours of the represented objects. This provokes a greater discretion in the definition of the apparent contour. In this case, the artist provides a much more precise definition of the architectural elements than in *Abbey in the Oakwood*. Of course,

the reason for such a decision can also be found in the different points of view of the two representations. In particular, the painting analysed in this case is depicted from a much closer distance, and therefore the representation required a greater level of detail, and also for this reason, the Eldena reference is much more recognisable in this painting.

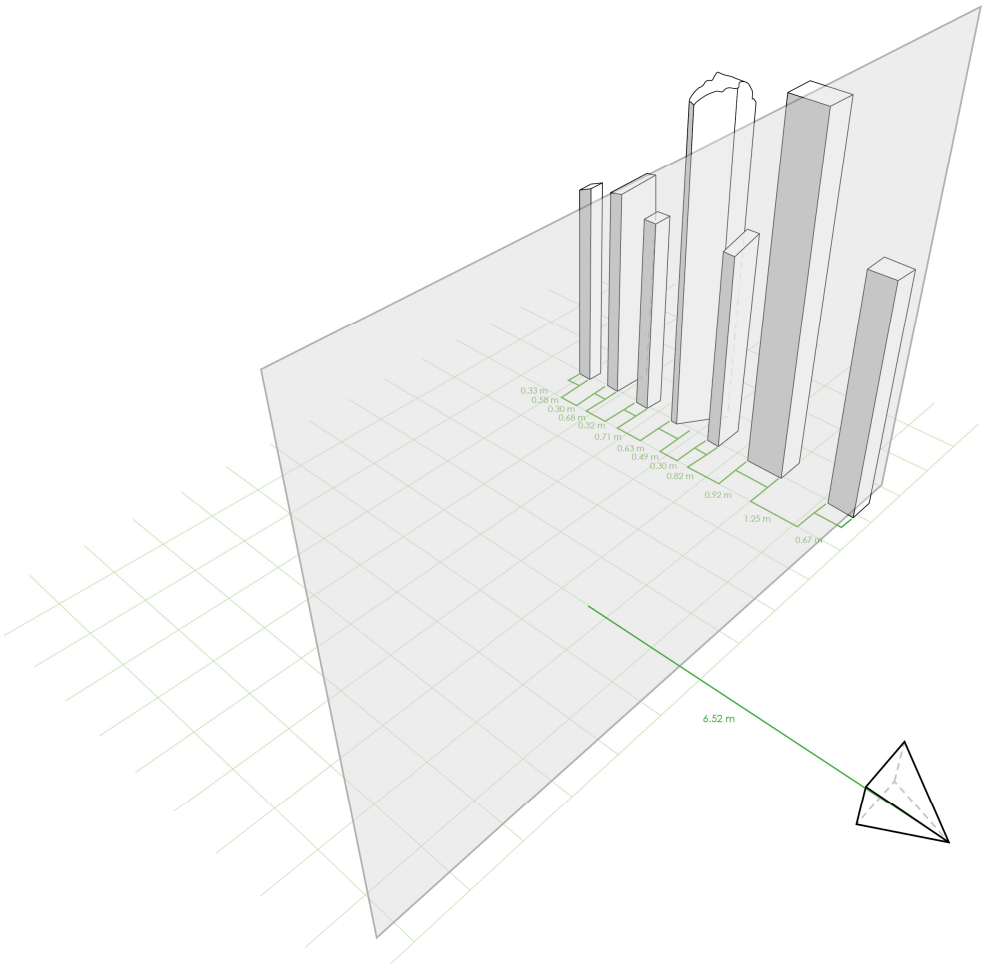


Figure 19. Scheme of the second 3D reconstruction scenario—distance of 6.52 m from the picture plane.

The obtained results have been described in the following Table 5:

Table 5. Second scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	1.25	0.67	1.87
2	0.82	0.92	0.89
3	0.49	0.30	1.63
4	0.71	0.63	1.13
5	0.68	0.32	2.13
6	0.58	0.30	1.93

With regard to the architectural space, in this case, we can detect an irregularity throughout the definition of the nave, as in the previous scenario. In particular, if we consider the comparison between the two different scenarios, we can see similarities in some intervals. Those similarities are described in the following Table 6:

Table 6. First and second scenario comparison.

N° Ratio	Ratio 1° Scenario	Ratio 2° Scenario	Difference
1	2.05	1.87	0.18
2	0.83	0.89	−0.06
3	1.78	1.63	0.15
4	1.48	1.13	0.36
5	1.71	2.13	−0.42
6	2.06	1.93	0.13

This evaluation confirms that there is a proportionality between the observer's distance from the frame plane and the spatial ranges. It is important to consider the contribution of the error relative to the interpretation of the apparent contour. In this second case, there is a significant irregularity in the spatial compositional scheme. Additionally, the lack of proportionality for all the analysed spans is due to the level of detail defined by Friedrich in the definition of the apparent contours. This leads to a greater interpretative error and therefore to very different proportions for the same spatial section. The following image describes the comparison between the two scenarios and the reconstruction of the church of Eldena. In this case, we have considered seven pillars in the reconstruction of the main nave, as Caspar David Friedrich has represented seven pillars in the painting *Ruined Monastery of Eldena near Greifswald*. In this case, the depth of the aisle is 26.22 m. In Figures 20 and 21, we displayed the difference between the two reconstruction scenarios and the reconstruction of the nave of the church in Eldena.

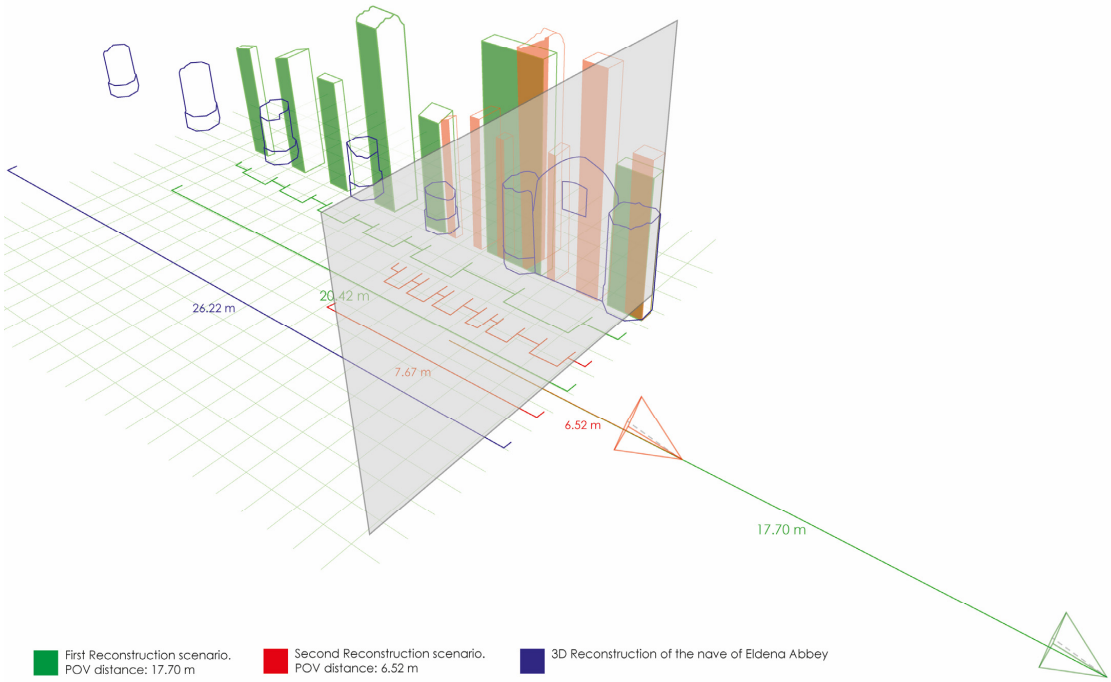


Figure 20. Comparison between the two reconstruction scenarios of the painting *Ruined Monastery of Eldena near Greifswald* and the 3D reconstruction of the central aisle of the Eldena Abbey.



Figure 21. Overlay of the 3 reconstructed scenarios in the perspective view of the observer 17.70 m away from the painted surface. In the background: Caspar David Friedrich, *Ruined Monastery of Eldena near Greifswald*, 1824/25, oil on canvas, 49 × 35 cm, Inv. No: A II 574, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Jörg P. Anders, Public Domain Mark 1.0 (Ibid).

2.2.3. Third Scenario Distance of the Observer from the Picture Plane of 31.00 m

It was defined to confirm the findings of the previous two scenarios and to determine if there was a compositional irregularity of architectural spatiality in all three scenarios.

The viewpoint was positioned 31.00 m from the picture plane in the third scenario. The results of this scenario are presented below in the Table 7:

Table 7. Third scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	3.52	2.49	1.41
2	4.11	5.66	0.73
3	3.18	1.45	2.19
4	2.96	2.23	1.33
5	3.39	1.88	1.80
6	3.06	1.38	2.22

In this case, we are faced with a significant irregularity among the different spatial portions, which follows the same proportional correspondences with the other two previous scenarios (always considering the interpretative error related to the apparent contour).

The results of the reconstructive scenarios of the architectural space depicted in *Ruined Monastery of Eldena near Greifswald* can be summarised in the following points:

- In *Ruined Monastery of Eldena near Greifswald*, the "densification" of the architectural spatiality, observed in the painting *Abbey in the Oakwood*, is not present. This is probably due to the fact that the two depicted subjects refer to the church of the monastery of Eldena with different degrees of relevance; in fact, as already mentioned, Caspar David Friedrich dealt with the representation of the architectural motif with the idea of 'fictitious archaeology' (*fiktiven Archäologie*—(Scholl 2007, pp. 182–83), with which

he manipulates the architectural motif according to his wishes in order to obtain an architectural object that can adhere to the ideas of his compositions.

- The spatial structure of the central nave of the church depicted in the painting *Ruined Monastery of Eldena near Greifswald* has an irregular proportional definition recognisable in the values of the ratio (Figure 22) between the sizes of solids and voids. This irregularity is also confirmed by the other analysed scenarios in this report.
- The results of the analysis of *Ruined Monastery of Eldena near Greifswald* are significantly affected by the fact that the outlines of the pillars depicted are obscured by vegetation, making it difficult to detect the projection of the apparent contour onto the image plane. This aspect is illustrated by the different ratio values for different spatial intervals in the different scenarios.

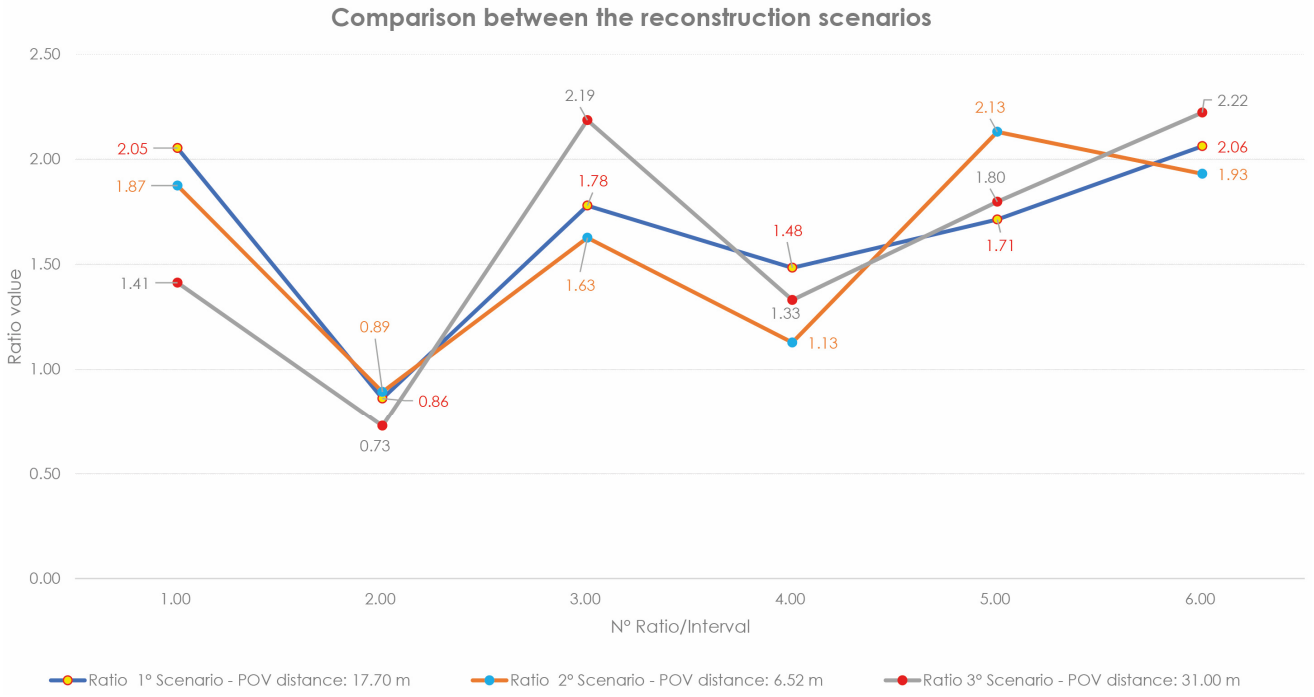


Figure 22. The values of the ratio for the painting *Ruined Monastery of Eldena near Greifswald*. There is no homogeneous compositional pattern that describe the development of the spatiality of the nave of the church represented by Friedrich.

In this section, we applied the reconstruction methodology to another painting that portrayed the Eldena Abbey, in order to understand if the findings related to the first painting are confirmed from the second painting.

2.3. Reconstruction of the Eldena Abbey in Greifswald, 17 March 1836 and Spatial Comparison

Another representation of the church of Eldena, elaborated by Friedrich, is a drawing called *The Eldena Abbey in Greifswald, 17 March 1836* (Figure 23) from a perspective that is very similar to the one proposed in the previous painting. In this case, Friedrich's representation appears to be an update of the previous configuration with some formal modifications that allow for a clearer and more distinct identification of elements in the composition, for example, the number of depicted columns and the details of the decoration of the columns. In this case, it is possible to identify seven supports, enabling a more comprehensive recognition and analysis of the space than in previous representations of the church. Furthermore, the lack of vegetation around the pillars and architectural elements in general makes the volumes of the pillars much easier to identify. The comparison with this third representation of Eldena is still very interesting, especially concerning the comparison

with the second painting of Eldena (*Ruined Monastery of Eldena near Greifswald)*, which seems to follow the same guidelines as the one we will analyse in this chapter. However, a closer look at the painting reveals a different scenario. In fact, if we study the vanishing lines of the surfaces of the pillars, we discover that the position of the vanishing point associated with them is shifted to the right of the representation, whereas in Eldena's previous representation, the vanishing point of the pillars was in the opposite position to the painted surface. This representation of Eldena allows us to focus specifically on the spatiality itself and on the representation of the architecture, also because it seems to be the focus of the painter himself in this drawing. This is evidenced by the fact that the whole representation is devoid of details of naturalistic elements, if the trees in the background behind the counter-facade of the church are not considered.



Figure 23. Caspar David Friedrich, *The Eldena Abbey in Greifswald, 17 March 1836*, 1836, watercolour over pencil, brush in grey, 235 × 228 mm, Inv. No. C 1937-415, Kupferstich-Kabinett, Staatliche Kunstsammlungen Dresden. Photo credit: Kupferstich-Kabinett, Staatliche Kunstsammlungen Dresden, Public Domain Mark 1.0[15].

After the identification of the vanishing point (Figure 24), different reconstructive scenarios have been created.

The first scenario, depicted in Friedrich's drawing, assumes an observer's distance from the picture plane of 10.72 m (Figure 25).

The results are noteworthy when compared with previous representations of Eldena. In particular, we already notice that the whole depth of the reconstructed aisle for this painting is 53.64 m. Such a measurement is strikingly different if we compare it with the dimensions of the other reconstruction scenarios of other paintings with comparable distances of the POV from the picture plane. It is even worth mentioning that the dimensions resulting from the reconstruction scenarios are not comparable with the dimensions of the

nave of a Gothic church. This was also the case for the first and second scenarios of *Ruined Monastery of Eldena near Greifswald*. Nevertheless, it is important to note that our focus is on the proportional composition of the spatiality of the nave depicted by Friedrich and its differences from that of the church in Eldena Abbey. The following are the ratio values for each spatial portion in the reconstructed scenario in Table 8:

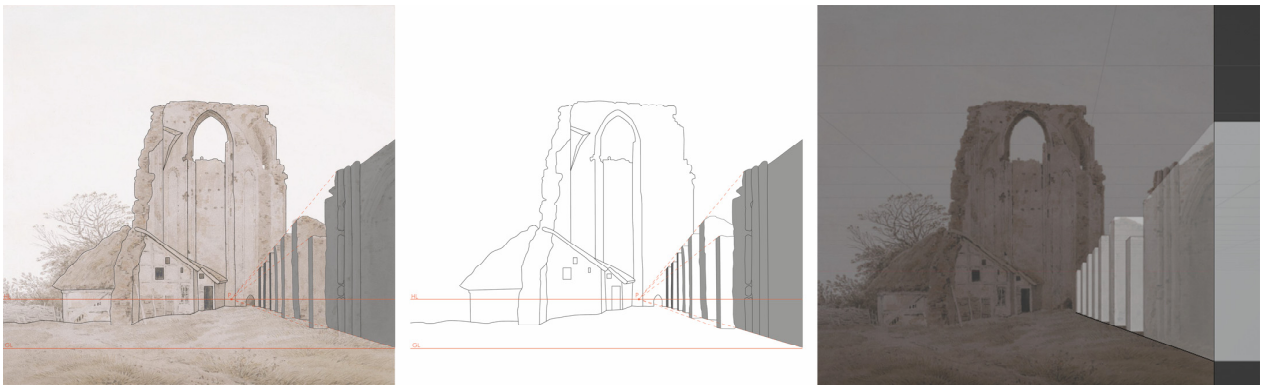


Figure 24. Detection of the vanishing point of the right side of the nave of the church represented in the painting *The Eldena Abbey in Greifswald, 17 March 1836* by Caspard David Friedrich and view of the modelling software Blender with the overlay of the watercolour. In the background: Caspar David Friedrich, *The Eldena Abbey in Greifswald, 17 March 1836*, 1836, watercolour over pencil, brush in grey, 235 × 228 mm, Inv. No. C 1937-415, Kupferstich-Kabinett, Staatliche Kunstsammlungen Dresden. Photo credit: Kupferstich-Kabinett, Staatliche Kunstsammlungen Dresden, Public Domain Mark 1.0 (Ibid).

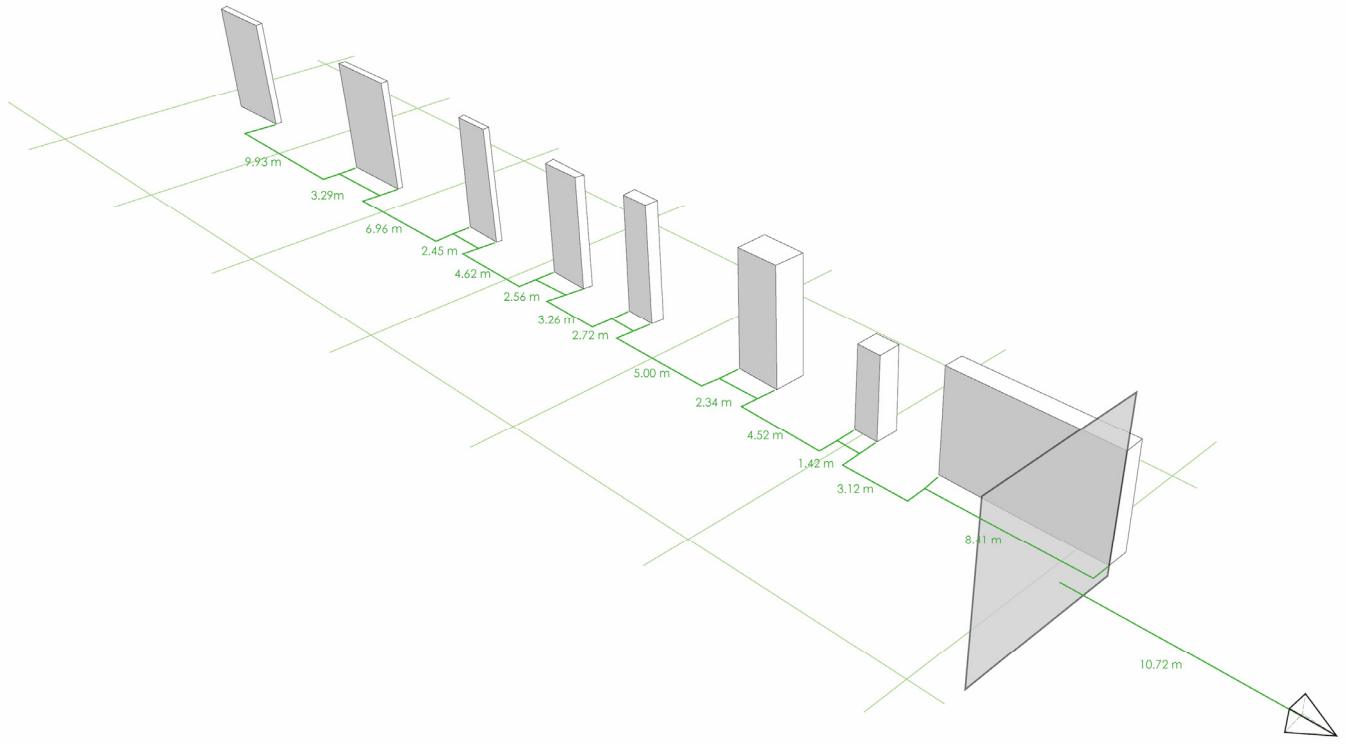


Figure 25. Scheme of the first 3D reconstruction scenario of the watercolour *The Eldena Abbey in Greifswald, 17 March 1836*—distance of 10.72 m from the picture plane.

Table 8. First Scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	3.12	8.41	0.37 *
2	4.52	1.42	3.18
3	5.00	2.34	2.14
4	3.26	2.72	1.20
5	4.62	2.56	1.80
6	6.96	2.45	2.84
7	9.93	3.29	3.01

* Ratio value not considered in the analysis of the architectural spatiality because of the irregular dimension of the pillar in comparison with the intercolumnar space.

There are some very interesting aspects to these results:

- The analysis excludes the first span due to a mismatch in size between the dimension of the pillar (in this case, a masonry septum as the opening of the span appears to be buffered) and the dimension of the intercolumniation. This makes it an exception within the structure of the church representation.
- The drawing depicts a church space with two main compositional schemes for the nave, separated by the fourth pillar which serves as a transitional element between the two compositional schemes for the nave.
- The ratios from the second to the fourth reveal a progressive reduction in the size of the intercolumnar spaces and, consequently, an increase in the size of the pillar dimensions. This type of spatial arrangement is similar to that found in the reconstructed scenarios of the *Abbey in the Oakwood*, where there is a "densification" of space in which the values of the intercolumniations progressively decrease. A notable difference between the compositional pattern of the two paintings is the fact that in *Abbey in the Oakwood*, the dimensions of the intercolumnar spaces decrease, whereas in *The Eldena Abbey in Greifswald, 17 March 1836*, the dimensions of the intercolumnar spaces in the space under consideration are irregular, but the dimensions of the columns increase, so much so that the ratio value decreases.
- Between the fifth and seventh ratios, there is a reversal of dimensions in the volume of the depicted church nave. Indeed, if we analyse the values defined in these intervals, we notice that the values of the intercolumniations tend to increase considerably. On the contrary, at least for the first two ratios, the value of the pillars decreases slightly and then increases considerably in the last ratio, but not enough compared with the increase in the intercolumnar spaces.

This spatial pattern has not previously appeared in our analysis in a homogeneous manner. Therefore, it is interesting to attribute it to a different way of describing Friedrich's representation of the architectural space. The following Figure 26 describes the values of the ratio the first reconstruction scenario.

After obtaining these results and findings from the first scenario, we decided to investigate the spatial arrangement of this work further. We studied another scenario where the POV was positioned 29.00 m away to determine if the proportional characteristics of the depicted nave remained the same or changed at a greater distance. In this case, the considered dimensions were not comparable to the one of the church of the Eldena Abbey due to the high distance from the picture plane. Therefore, the dimensions in 3D were also increased for both columns and intercolumnar areas, so that the depth of the reconstructed aisle was 164.73 m. The results of this scenario are described in Figures 27 and 28 and Table 9.

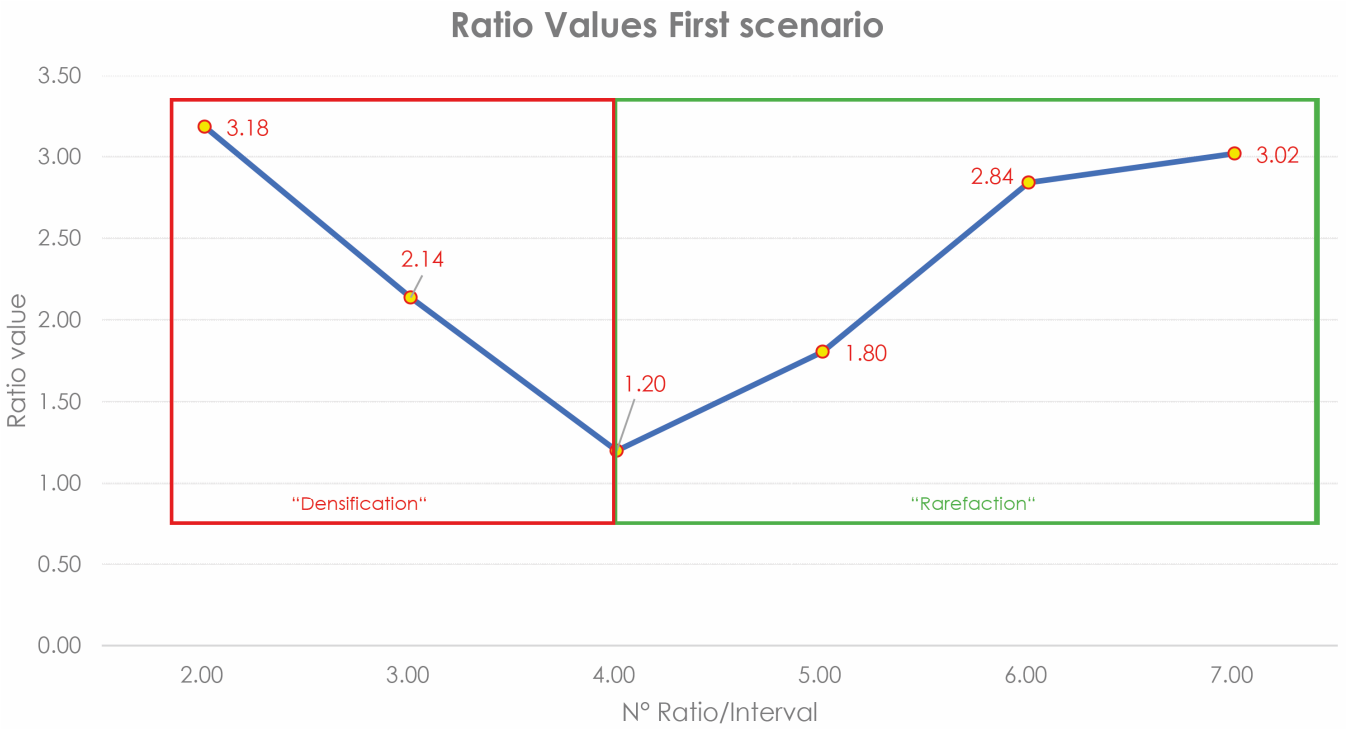


Figure 26. This graph describes the trend related to the ratio and the configuration of the space of the central nave of the church. In particular, the "densification" and "rarefaction" of the space is emphasised.

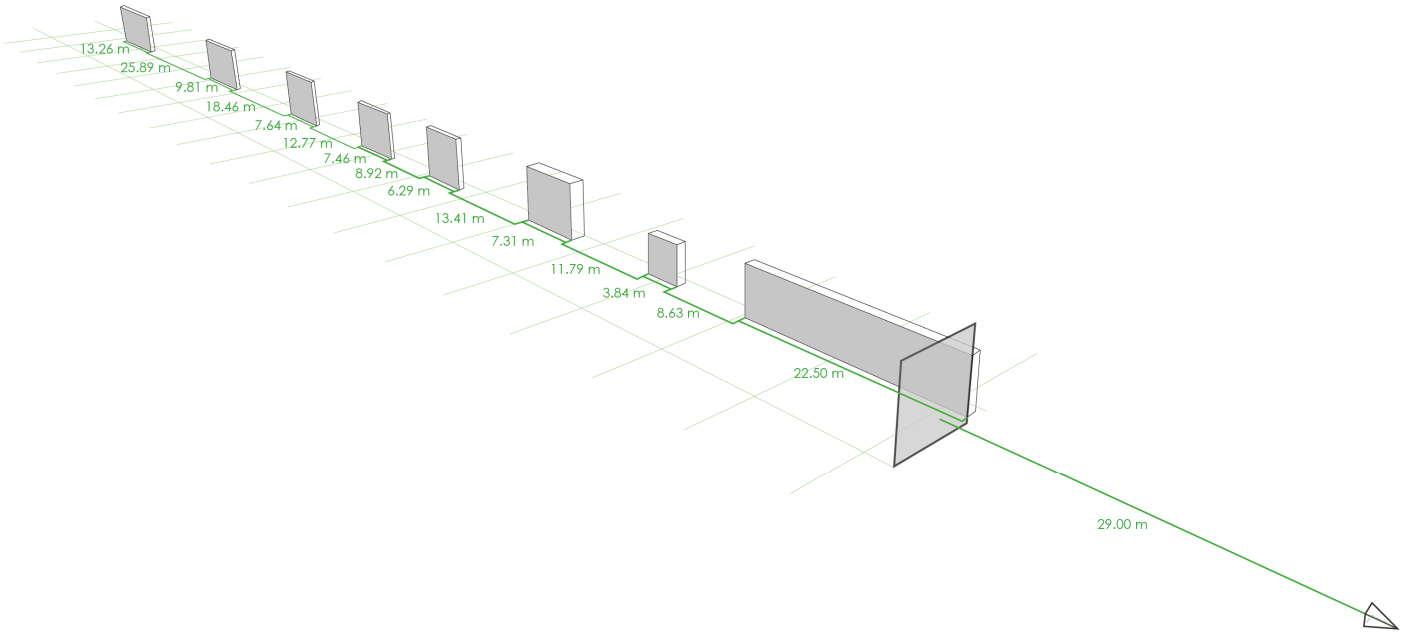


Figure 27. Scheme of the second reconstruction scenario of *The Eldena Abbey in Greifswald, 17 March 1836* (1836).

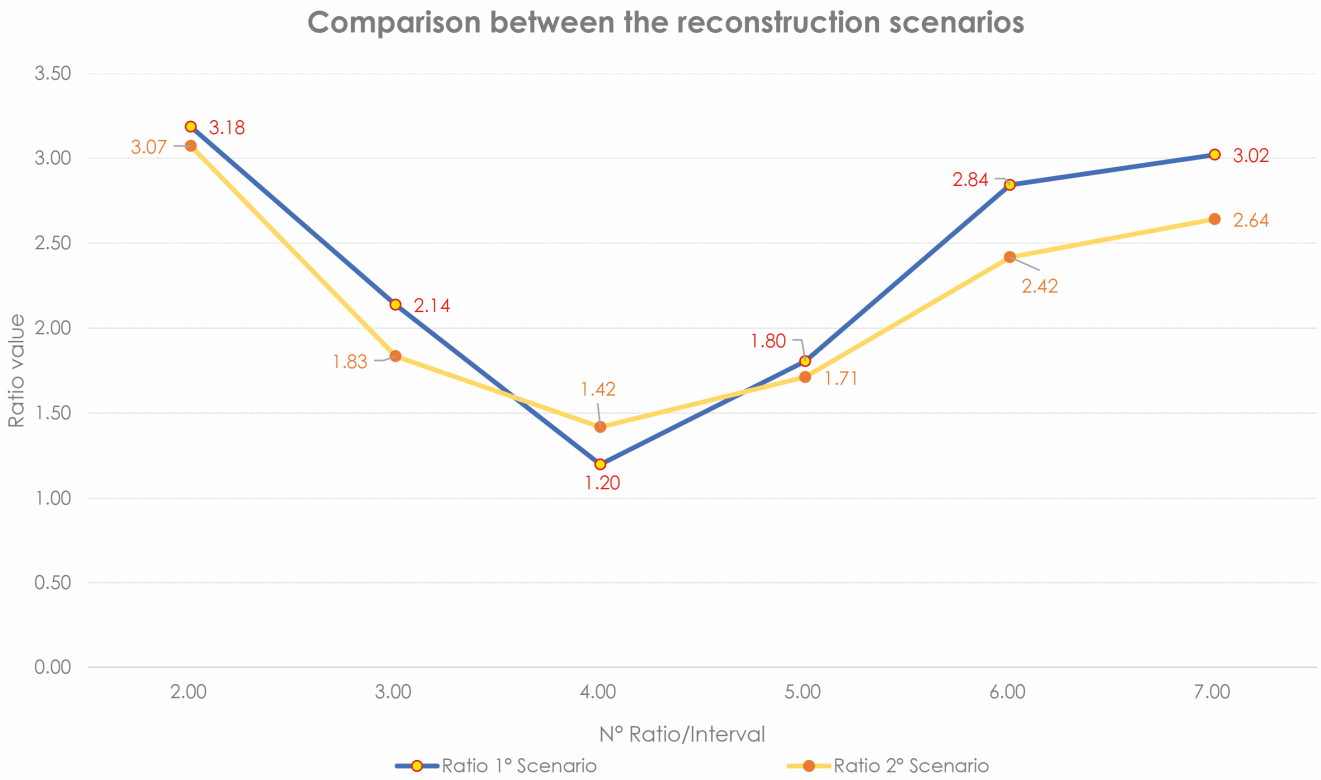


Figure 28. The comparison between the two reconstruction scenarios. The trend of the first scenario is confirmed also in the second one.

Table 9. Second scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	8.63	22.50	0.38 *
2	11.79	3.84	3.07
3	13.41	7.31	1.83
4	8.92	6.29	1.42
5	12.77	7.46	1.71
6	18.46	7.64	2.42
7	25.90	9.81	2.64

* Ratio value not considered in the analysis of the architectural spatiality because of the irregular dimension of the pillar in comparison with the intercolumnar space.

The outcomes of this second scenario are described in Table 9:

The spatial configuration follows a similar pattern to the first scenario, with an initial "densification" and some differences. However, it then shows a contrary trend to the latter, with the space between the pillars expanding greatly again, although with some differences to the first scenario in terms of the size of the pillars:

- In the "rarefaction" phase of the space, the dimensions of the pillars remain unchanged. This is in contrast to the first scenario where an increase in the intercolumniation resulted in a decrease in the size of the pillars.
- The increase in intercolumniation values during the expansion phase is more pronounced than in the previous scenario. The spaces between the columns increase by a greater amount when moving from one space range to another.

At the proportional level, there are similarities between the two scenarios. However, the spatial structure is similar, but the proportions differ quantitatively due to the variation in the observer's distance from the picture plane.

The spatial definition of the first scenario is confirmed as displayed in the spatial comparison between the two scenarios in Figure 29.

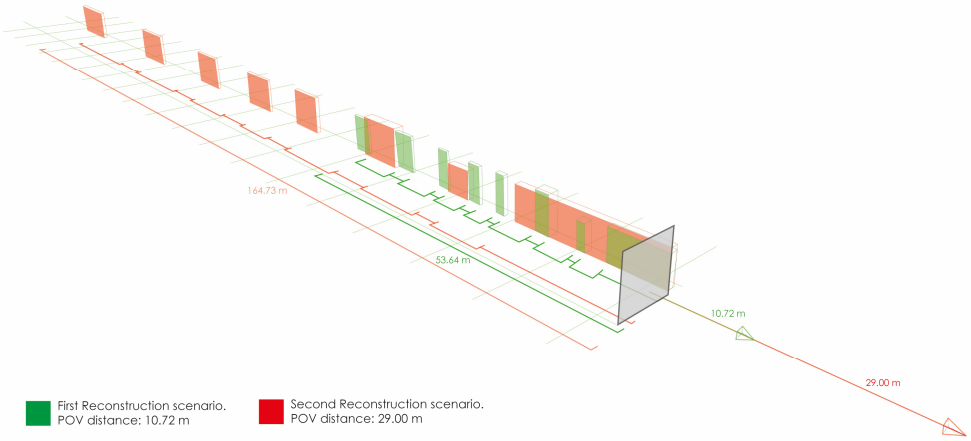


Figure 29. The comparison between the two reconstruction scenarios of *The Eldena Abbey in Greifswald, 17 March 1836* (1836). In both scenarios, we can state the huge difference concerning the depth of the reconstructed elements in comparison with the other two paintings.

Given the possibility of a more precise analysis of the architectural substrate of this representation, a spatial comparison with the reconstruction of the Critical Digital Model of Eldena can be taken into account. This type of comparison helps us to investigate the extent to which the painter synthesised and reworked the dimensions of Eldena's church through his representation.

To compare the reconstruction with the architectural survey of the church, we created an appropriate scenario. We took one measurement from the architectural survey of the church and applied it to the reconstruction of the nave. This allowed us to see how far the other measurements diverged from the ratio values of the church in Eldena surveyed by Balthasar in 1857[16].

In this case, the distance between the observer and the picture plane is defined by the measurement of the Critical Digital Model of the fourth pillar (1.57 m similar to 1.52 m—First reconstruction scenario) of the nave. The distance to the picture plane is similar to the first scenario, at 10.30 m (Figures 30 and 31). The dimensional feature is also comparable to the first scenario. The values for this third scenario are listed below (Table 10):

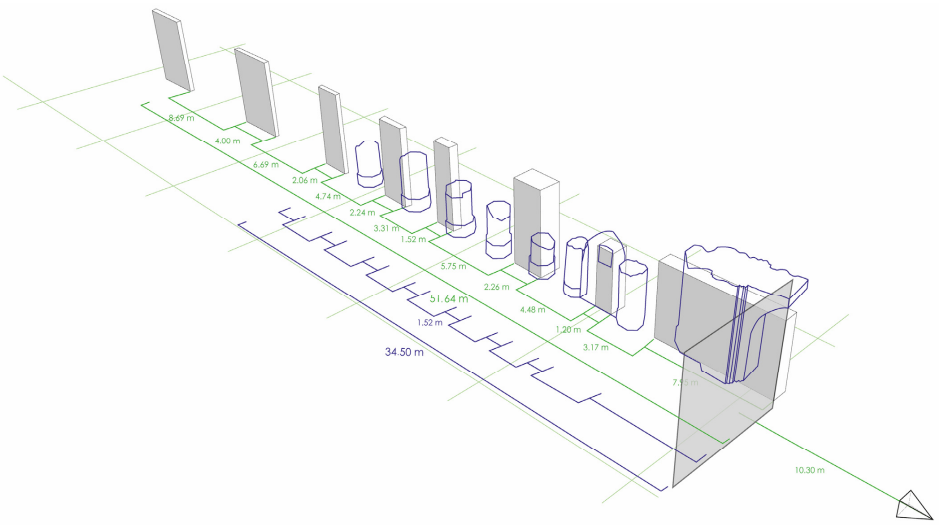


Figure 30. Scheme of the third reconstruction scenario of *The Eldena Abbey in Greifswald, 17 March 1836* (1836) and the 3D critical reconstruction of the church of Eldena (in purple).



Figure 31. Overlay of the 3 reconstructed scenarios in the perspective view of the observer 10.72 m away from the painted surface. In the background: Caspar David Friedrich, *The Eldena Abbey in Greifswald, 17 March 1836*, 1836, watercolour over pencil, brush in grey, 235 × 228 mm, Inv. No. C 1937-415, Kupferstich-Kabinett, Staatliche Kunstsammlungen Dresden. Photo credit: Kupferstich-Kabinett, Staatliche Kunstsammlungen Dresden, Public Domain Mark 1.0[17].

Table 10. Third scenario values.

N° Ratio	Intercolumniation (m)	Pillar (m)	Ratio Values
1	3.17	7.95	0.40 *
2	4.48	1.20	3.73
3	5.75	2.26	2.54
4	3.31	1.52	2.18
5	4.94	2.24	2.21
6	6.69	2.06	3.25
7	9.20	2.70	3.41

* Ratio value not considered in the analysis of the architectural spatiality because of the irregular dimension of the pillar in comparison with the intercolumnar space.

Here, it is evident that there is a significant difference between Friedrich's reconstruction of the representation and the dimensions of Eldena's reconstruction.

Friedrich's pattern of the structure of space is confirmed, except for the last span where the ratio begins to decrease in an unusual way. This reconstruction confirms that Friedrich's architectural space reconstruction, excluding the aesthetic connotation of decorative elements, does not rigidly adhere to the main reference, i.e., Eldena's church.

3. Materials and Methods

In order to approach the 3D reconstruction of Friedrich's works of art in the church of Eldena, it was essential to develop a methodology for reconstructing the depicted scene using a scientifically reliable method.

3.1. Apparent Contour

As there is no metric reference and no information about the position of the observer's point of view in the scene painted by Friedrich, the most effective elements on which to base the reconstruction of the church 'designed' by Friedrich are the apparent contours of the architectural elements. Previous studies have enabled the definition of the outlines of the contours defined by Friedrich in his underdrawing on the canvas through Infrared Reflectographic analyses (Mösl 2020, p. 66). In fact, these contours describe the size of the object in a given position in space and the possibility of defining both the foreground and background surfaces of a depicted object. Retracing the apparent contours of the depicted elements makes it possible to define their depth and position in 3D digital space. In order to apply this method to the church columns, certain assumptions were made:

- The painter has placed all the columns on the same vanishing line and, therefore, at least as far as the base of these elements is concerned, they are all aligned on the same plane (this assumption also seems to be confirmed by the reconstruction of the vanishing lines). This orientation of the columns was also assumed to be perpendicular to the plane of the image.
- The second assumption is that the apparent contours are not sufficient to define the size of the objects; the detection of the vanishing point by the vanishing lines allows the position of the observer in the image plane to be defined. This is not sufficient to determine the position of the observer in 3D space. However, this assumption led us to create different reconstruction scenarios.

However, these two assumptions alone are not sufficient to accurately define the position of the observer in space; in fact, apparent contours and vanishing lines (and thus vanishing points) are not sufficient to objectively define the dimensions of the columns. For this reason, different scenarios were analysed, taking into account different observer positions, in order to analyse the proportional aspects resulting from the perspective structure developed by Friedrich.

3.2. 3D Modelling

Among the analytical methods, 3D modelling is worth mentioning as an analytical tool in its own right. It is important to emphasise the level of understanding that 3D modelling software allows compared with other analogue or at least two-dimensional tools (or methods).

In particular, the potential of this tool can be summarised as follows:

- A simultaneous understanding of the structure of the representation from different views, with the possibility of verifying the consequences of modifications related to one view (e.g., plane view) directly on another view, which could be the perspective view of the painting itself.
- The opportunity to make a metric and dimensional comparison between the elements depicted by Friedrich, and thus to compare the representation of the church painted by the Romantic painter with the Abbey of Eldena at the time when Friedrich painted it.
- The possibility of reconstructing in space the positions of the viewpoints used to represent the individual objects belonging to the architectural complex depicted by Friedrich. In this way, it is possible to reconstruct the German painter's compositional system, which is based on the constitution of a pictorial scene in which various elements, even those that have nothing to do with the architectural reference depicted, are integrated into the pictorial scene.

In order to gain an even clearer understanding of the metrical differences in Friedrich's depiction of the architectural motif, a reconstruction of Eldena Monastery has been undertaken, taking into account the metrical drawings that date as close as possible to the time when Friedrich painted this religious architecture. In addition to the survey drawings made by Balthasar in 1857[18], the reconstruction also took into account preparatory sketches by Friedrich himself. This choice was made in order to reconcile the painter's impressions on site with the technical survey drawings provided by Balthasar.

This section outlines how the use of apparent contour projection and the 3D-modelling tool can be combined to create a methodology that allows reconstructive scenarios of Friedrich's work to be modelled. In this case, the open-source software Blender (version 3.4) was used for the reconstruction, as it not only offers all the possibilities of CAD software but also the ability to model and sculpt shapes in an intuitive and agile way. The software has been used extensively to analyse a wide range of scientific topics across a variety of disciplines, making it a very powerful speculative tool for analysing and reporting research results. The great flexibility of this software is due to the great possibility of customising the functions within the software, thanks to a large number of add-ons that allow the different specific aspects of modelling to be handled individually: from the modelling of a topographic surface to the dimensioning of the layout elements of the model. This enormous variety of functions not only relates to the possibility of importing file types for different purposes but, above all, to the ability to export efficiently in different formats, such as Wavefront (.obj), FBX (.fbx), Collada (.dae) and Stl (.stl), among many others. As a result, the model created in Blender contains not only the geometry of the object but also its texture and information about the lighting of the scene and the light source itself, the transformation information of the objects and their animations, thanks to the various export possibilities of the software. The model created in Blender can also be easily implemented and imported into various rendering engines, in addition to those within the software itself (Eevee and Cycles), there is also the possibility of rendering the model on other tools such as LuxRender, RenderMan and Yafaray. On a scientific level, in order to prove the power of such software, it is appropriate to mention a number of studies in different disciplines that have used Blender as a specific analysis tool or that have used Blender as a visualisation tool for specific research elements.

For example, Blender has been widely used in biology to visualise and analyse the structures of proteins and their composition. Specific software has been developed to analyse the morphing and molecular structure of peptides (see also Andrei et al. 2012; Zini et al. 2010).

In other cases, the potential of Blender and its ability to visualise objects from different disciplines in three-dimensional structures has led to its use in astrophysics. In this case, Python packages have been created to visualise astrophysical datasets for study in a three-dimensional interface (see also Naiman 2016).

In the field of architectural representation, Blender is a very powerful tool and certainly has a very strong connection to the design and communication aspect of built or designed space. Research into the use of this tool within the field of architectural representation is extensive, and once again the flexibility of this tool is leading researchers to explore its potential in very different areas. A very important part of architectural modelling is certainly related to the management and use of the various tools and add-ons within Blender, and a number of studies deal specifically with determining which tools and add-ons can be used for each specific modelling domain (see also Brito 2008; Dounas and Sigalas 2009). Some of the literature has therefore been concerned with trying to give an idea of how such a versatile tool might structure specific workflows to be used within the architectural modelling and design process. In the specific field of artwork analysis and reconstruction, a tool such as Blender is undoubtedly a continually evolving entity.

The choice of software with which to analyse a given work may depend on a multitude of disparate circumstances. It is evident that the analysis of specific themes within an artwork, such as the representation of an architectural object, can be conducted using a variety of software. Consequently, in some instances, the name of the software employed is not disclosed, and 3D modelling becomes the primary method for comprehending and analysing the represented artefact (see also Sdegno 2004, 2008). In our case, one of the primary factors that led us to utilise a software such as Blender is its comprehensive editing and sculpting capabilities, as well as the ability to employ multiple viewports concurrently to manage the representation of the painting in digital space, a feature common to most modelling software.

The capacity to integrate perspective (the observer's perspective of the painting) and top orthographic views (Figure 32) enables a comprehension of how the elements modelled within the view of the painting are situated in planar space (top view). This facilitates the straightforward examination and supervision of the modelling of the represented elements and the immediate comprehension of the consequences of any alterations directly from the perspective view relative to the painting.

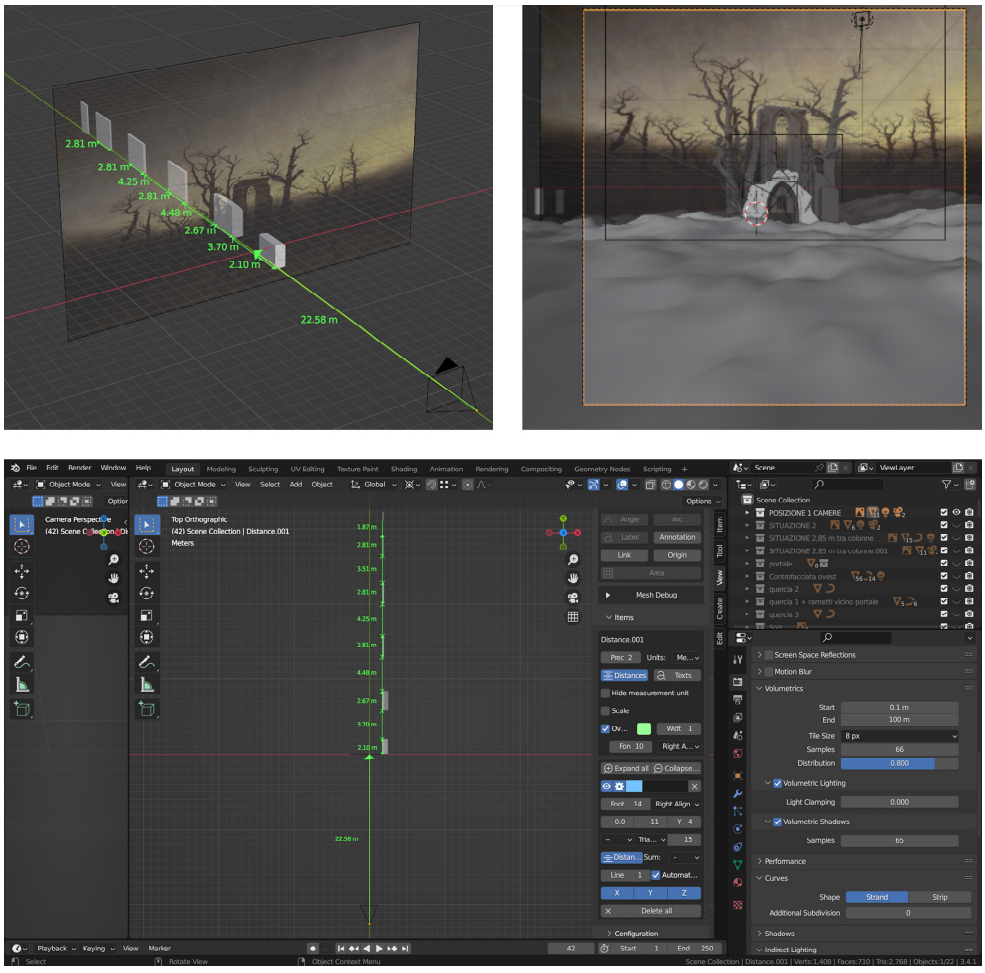


Figure 32. The reconstruction of the spatiality of the nave of the church in the painting *Abbey in the Oakwood* from three different views: perspective (**top left**), observer—painting view (**top right**) and topographical view (**bottom**). In the background: Caspar David Friedrich, *Abbey in the Oakwood*, 1809/10, 110.4 × 171 cm, oil on canvas, Inv. Nr.: NG 8/85, Staatliche Museen zu Berlin, Nationalgalerie. Photo credit: Staatliche Museen zu Berlin, Nationalgalerie/Andres Kilger. Public Domain Mark 1.0[19].

4. Discussion

This section focuses on how this research could be integrated into the existing scholarship on the subject of 3D reconstruction of paintings and 2D images. It will also examine the potential errors that could be introduced during the interpretation of Friedrich's depiction. The methodology presented differs from previous reconstruction methods used for 3D reconstruction of photographs or paintings. In this case, the use of the projection of the apparent contour onto the picture plane enables the reconstruction of the pillars of the church space depicted by Friedrich in the various artworks in a detailed manner, without having any information related to their measurements. It is evident that this approach, when considered in the context of the objective reconstruction of a two-dimensional representation of space, introduces significant limitations in terms of the scientific reliability of the reconstruction (from a metrical perspective). The objective of this study was not to provide an objective and metrically reliable reconstruction. Rather, the aim was to gain insight into the spatial proportions that the artist had chosen to structure the ecclesiastical space, or, in any case, how Friedrich had reinterpreted the reference of the monastery of Eldena in these three artworks. Other research studies for the reconstruction in three-dimensional space of paintings have attempted to break down the space of the painting into a 'perspective room' in which elements belonging to the different portions in the perspective room ('ceiling', 'walls' and 'floor') are identified in the representation (Carfagni et al. 2012; Horry et al. 1997; Volpe et al. 2014). Once a gradient relative to each of the surfaces has been defined, the foreground elements are reconstructed either according to simple volumes or according to a pop-up book structure. This type of definition attempts to reconstruct the depth of the composition through a depth map that describes the position of the objects in a reference distance that is configured (as in the work of Horry et al. (Horry et al. 1997) between an extreme background surface and the picture plane. Although this methodology is effective and innovative, it is not applicable to the case of Caspar David Friedrich due to the compositions of the same painter, which do not consider the presence of a background with an easily identifiable geometric structure (Grossmann et al. 2002; Liebowitz et al. 1999). Similarly, in the analysed representations, it is not possible to clearly identify a background plane that serves as a background for the spidery mesh (Horry et al. 1997). This issue is of particular importance with regard to Friedrich's works, as the presence of an unrestricted space in depth does not allow a simple reconstruction of the 3D space, as has been achieved in studies for the visually impaired and for the reconstruction of works of art in the form of 3D prototyped bas-reliefs (Carfagni et al. 2012; Furferi et al. 2024; Volpe et al. 2014). Indeed, in the case of the artworks reconstructed in this study, it was possible to reconstruct a background that would then be used as the basis for reconstructing the elements of the relief representation. This is also not applicable to Friedrich's representations, in which a significant disparity can be observed between the elements depicted in his paintings (e.g., architectural elements) and the background of the representation. This disparity is such that the architecture appears to be immersed in a much larger landscape structure, suggesting that it is a point element within the painting (e.g., in *Abbey in the Oakwood*). In the case of *Abbey in the Oakwood*, reconstructing the spatiality by considering the church façade as the background would be erroneous, as it would ignore the presence of the trees in the background of the façade and other elements such as the tombstones in the snow-covered ground. Furthermore, the methodology of reconstructing these bas-reliefs is intended to reconstruct the scene for visually impaired users and not to reconstruct the scene with metric objectivity (Carfagni et al. 2012; Furferi et al. 2024; Volpe et al. 2014). The proposed methodology is structured around the metric-proportional reconstruction of the architectural apparatus of the church designed by Caspar David Friedrich. This approach allows for an understanding of the spatial reasoning behind the elaboration and

reinterpretation of the architectural object in his artwork. In this context, other studies have sought to address the 3D reconstruction of paintings through a proportional comparison between the elements represented. Among these, the work of Zisserman, Criminisi and Liebowitz is worth mentioning (Liebowitz et al. 1999). They addressed the reconstruction of Piero della Francesca's paintings (previously mentioned) and 3D modelling from individual images and photographs. They carried out the 3D reconstruction by exploiting geometrical constraints to reconstruct the individual components required to consistently model the representation in three-dimensional space (Grossmann et al. 2002; Lourakis and Argyros 2007; Wan and Yang 2014). These approaches, although innovative in resolving certain contingencies of the case, are not applicable to the representations of Eldena or by Caspar David Friedrich. This is because the geometric characteristics and perpendicularity relationships of a photograph are not applicable to a painting. Furthermore, for Friedrich in particular, geometric and perspective rules and representation were not the main goals of his representations. The artist was more focused on positioning the figures and motifs in the scene in relation to the sense he wanted to convey through his depiction (Homberg 1974, p. 133). In contrast, the Greifswald painter adapted and interpreted the scene and the surrounding reality in a manner that conveyed his personal vision of reality (Homberg 1974, p. 133). This approach has prompted art historians to engage in continuous debate regarding the true interpretation of Friedrich's works, leading to the emergence of diverse and conflicting opinions. Indeed, research into the interpretation of Friedrich's works analysed in this article has focused a great deal on the iconographical analysis of the artefacts represented, as in the case of *Abbey in the Oakwood* (Scholl 2004, pp. 90–92). However, it has also led to a new conception of their interpretation, which has been informed by an analysis of the spatiality of the works themselves. The analysis of the spatiality of Friedrich's works has a specific function when placed within the context of this research field. It is necessary to understand how the interpretation of these works may have been influenced by the variation in the conception of spatiality resulting from the insights gained from the research. The example provided above, concerning the interpretation of the *Abbey in the Oakwood*, is an exemplary case study of how the spatiality of the religious building may have influenced art historians' interpretation of Friedrich's work and the analysis of his conception of the philosophy of history (Scholl 2007, pp. 183–84). Research that focuses on Friedrich's construction of spatiality and its proportionality stems precisely from the need to expand the discourse related to the analysis of its spatial representation method. Once more, we encounter statements made by Schmitt that emphasise Friedrich's interest in a specific use of proportions with regard to the altimetry of architectural elements. The proposed research aims to analyse Friedrich's handling of proportions not only from an altimetrical point of view but also from the point of view of the depth of space, with the intention of understanding whether there was an *a priori* reasoning with which the artist approached the architectural motif. The detection of such reasoning has been achieved through the analysis of the central nave of Friedrich's representations of the church of Eldena, which serve as an effective case study of the compositional pattern displayed by Friedrich with regard to the architectural motif.

4.1. How the Research Answers the Research Questions?

This study highlighted how the composition of Friedrich's painting influenced the depiction of architecture, and how the painter's use of perspective provides an interpretation of space tailored to the perceptual purpose of the depiction. The painter interpreted the spatiality of the church in such a way as to emphasise the longitudinal dimension of the nave in order to achieve a more pronounced perspectival effect. This effect is highlighted by the analysis of the scenarios and the study of the proportions, which emphasise a pro-

gressive reduction in the intercolumnar spacing and thus a densification of the columns towards the façade of the church.

The use of 3D modelling as an analytical tool for pictorial space enables a proportional study of different compositional scenarios in an intuitive and simple manner. Checking the spatial composition of the painting from different views allows for a more direct understanding of the differences between scenarios with the same apparent contour. This tool provides immediate awareness of changes in different scenarios compared with analogue methodologies. The usage of 3D modelling software also allows for the straightforward quantification and analysis of scenes on a metric-proportional level.

4.2. Limitations and Possible Errors

One of the most interesting aspects that can be addressed in this study is certainly the analysis of the interpretation of the apparent contour of Friedrich's painting and how it can then impact the dimensional aspect of the 3D reconstruction. The assumptions that were taken into account to carry out an analysis of the spatiality of the nave of the church represented in the three artworks depicted by Friedrich: *Abbey in the Oakwood*, *Ruined Monastery of Eldena near Greifswald*, *The Eldena Abbey in Greifswald, 17 March 1836*, must be stated in order to give the reader a clear definition of how the study was carried out and to clarify certain limitations of the study:

- As the base of the pillars was not always visible in the picture, it was assumed that in Caspar David Friedrich's works, the bases of the pillars were aligned in the same direction, ignoring any differences between one pillar and the other being inwards or outwards. This assumption was also supported by the fact that the upper parts of the pillars follow the same vanishing line and therefore belong to the same orientation, perpendicular to the picture plane.
- The surfaces of the columns in the space of the church were considered to be perpendicular to the picture plane.
- Given that the tops of the columns are flat and perpendicular to the picture plane, it was also possible to see that not all the columns followed the same vanishing lines. More specifically, it can be seen that the pillar in the foreground vanishes at a slightly lower point than the other five pillars behind it. The possibility of detecting several vanishing points does not limit the possibility of reconstructing the scene in 3D.
- The main limitation is related to the error of interpretation in the reconstruction of Friedrich's paintings, as it strongly affects the dimensions of the reconstructed elements. This error is analysed in the following section.

4.2.1. The Graphical Error and Interpretation of the Apparent Contour

We have focused on the three-dimensional reconstruction of the nave as depicted by Friedrich in the three paintings mentioned above, in order to show how the painter handled the spatiality of this part of the architectural motif in the paintings. This is, of course, a simplification in terms of the spatiality of the whole representation, but at the same time, since it is possible to compare the result of the reconstruction with the proportions of the nave in a space with a particularly regular structure (with similar proportions between bay and pillar), it allows us to understand the relationship between Friedrich's representation and its reference in a proportional sense. In the same way that the study of spatiality was simplified due to the spatial complexity of Friedrich's depiction, it was decided to report the analysis of the impact of the interpretive error within the first scenario of the painting *Abbey in the Oakwood*, in order to give the reader a clear idea of the relevance of this error to the results, and to demonstrate that this error, although relevant, does not invalidate the result of the 'densification' of the spatiality of the architecture depicted in the

painting. During the reconstruction of the spatiality of the painting, it has been noted that the reproduction of the apparent outline and the definition of the depth of the columns are influenced by the discretion involved in interpreting the contour lines of the underdrawing. Indeed, when considering the tracing of the outline of the columns, it must be borne in mind that the decision to draw a particular outline implies a certain error due to the fact that the thickness of the drawn outline corresponds to a very significant dimension in three-dimensional space. This error is determined by a number of factors:

- The distance of the point of view from the picture plane. The farther the viewpoint is from the picture plane, the greater the depth of the scene in space. The more the observer is shifted away from the picture plane, the greater the error influences the 3D reconstruction.
- The thickness and precision of the line designed by the painter, which, however thin it may be, especially for objects in the background, leads to considerable risk of misinterpretation.

In order to define how this type of range (related to the outline's thickness) affects the dimensions of the objects in the 3D reconstruction. We will define a range of values relating to changes in the dimensions of each column with regard to the decision to trace the apparent contour with a given profile. This range will be defined for each of the two scenarios described above:

4.2.2. First Scenario: Distance of the Observer from the Picture Plane of 22.58 m

Two surfaces were identified for each pillar: one defining the apparent contour (front), and another defining the boundary of the pillar and thus its depth in three-dimensional space (back). For each of these surfaces, a was defined (Δ), derived from the thickness of the lines designed by the painter. The order of the columns is the same as in the previous scenarios. It is important to note that the third digit after the decimal point has been added, unlike the values of the reconstructed scenarios, because, especially for the intervals close to the image plane, greater numerical accuracy allows a clearer perception of the difference between the values obtained.

1. I Column:
   - Front: $\Delta = \pm 0.077$ m
   - Back: $\Delta = \pm 0.125$ m
2. II Column:
   - Front: $\Delta = \pm 0.194$ m
   - Back: $\Delta = \pm 0.266$ m
3. III Column:
   - Front: $\Delta = \pm 0.458$ m
   - Back: $\Delta = \pm 0.469$ m
4. IV Column:
   - Front: $\Delta = \pm 0.615$ m
   - Back: $\Delta = \pm 0.749$ m
5. V Column:
   - Front: $\Delta = \pm 0.621$ m
   - Back: $\Delta = \pm 0.751$ m
6. VI Column:
   - Front: $\Delta = \pm 0.534$ m
   - Back: $\Delta = \pm 0.527$ m

As can be seen, the value of the interval continues to increase up to the fifth pillar. This phenomenon is related to the fact that the reconstructed features for the fifth and sixth pillars are much sharper and clear-cut, and therefore the Δ also becomes smaller. The relative size of the individual columns (which also decrease in depth) also influences the fact that the gap cannot become too large in comparison with the size of the column itself.

4.2.3. Second Scenario: Distance of the Observer from the Picture Plane of 13.20 m

1. I Column:
   - Front: $\Delta = \pm 0.026$ m
   - Back: $\Delta = \pm 0.081$ m
2. II Column:
   - Front: $\Delta = \pm 0.119$ m
   - Back: $\Delta = \pm 0.165$ m
3. III Column:
   - Front: $\Delta = \pm 0.287$ m
   - Back: $\Delta = \pm 0.282$ m
4. IV Column:
   - Front: $\Delta = \pm 0.223$ m
   - Back: $\Delta = \pm 0.354$ m
5. V Column:
   - Front: $\Delta = \pm 0.418$ m
   - Back: $\Delta = \pm 0.342$ m
6. VI Column:
   - Front: $\Delta = \pm 0.254$ m
   - Back: $\Delta = \pm 0.190$ m

As far as the range due to the retracing of the apparent contour is concerned, it is important to underline the magnitude of the values as being very different depending on the scenario. In fact, if the observer is closer to the picture plane, the maximum value of the delta is 0.418 m, while in the first scenario (in which the observer is 22 m away from the picture plan), peaks of 0.751 m are reached. This underlines the fact that the distance of the observer from the picture plane modifies the impact that the tracing of the apparent contour has on the dimensions of the depicted objects which are reconstructed in three-dimensional space.

The error we analysed for the first two scenarios leads us to insert new considerations regarding the reconstruction scenarios themselves. In fact, we can analyse the same scenarios considering the limit cases identified by the error, i.e., the cases in which the apparent contour line drawn is at the two extremes of the originally traced contour. Although it is very complicated to consider these limit cases as a plausible response to the redrawing of the apparent contour, these cases must be analysed as they give us a perception of how the reconstruction of the spatiality of the church depicted by Friedrich is influenced by the decision made on the outline related to the depicted elements. Moreover, the measurements considered in the previous scenarios were included in the limit cases as the intermediate case has been modified to create the two extreme cases. For this reason, an afterword has been added in which the findings and different measurements of the analysed scenarios and their limit cases have been compared with each other. This allows us to understand whether the findings that are related to the scenarios are valid for any of the cases related to these apparent contour outlines.

The results of this comparison have been synthetised in some summarising graphs, in order to make it clearer how the decision of where to locate the outlines of the apparent contour influences the spatial framework created by Friedrich.

The first "extreme" scenario, in which the outlines have been drawn in the most external surface of the pillars, are represented by Friedrich. In this case, as far as the measurement examined in the first scenario is considered as the "average point" of the outlines, the dimensions of the elements of the composition have been increased by half of the "Δ" in the case of the dimensions of the pillar. The opposite has been achieved with the gaps between the pillars. In this case, it is interesting to summarize the results of the comparison through graphs as they are the most straightforward methodology that enables us to identify a clear range of measurements influenced by the retracing of the apparent contour. This makes it easier to understand which could be the "extreme" dimensions for each element of the representation between the two "extreme" scenarios and the one we considered during the analysis. One of the most important things that is worth mentioning is that the error has been processed only considering the depth of both the pillars and gaps (progressing to the vanishing point of the representation). It is vital to mention such a detail because the choices related to the retracing process of the apparent contour affect not only the depth of the architectural element but also the width and the height of the elements of the composition. We decided to analyse only the depth dimension because it is the one that is influenced the most by the exchange of scenario. In fact, if we consider only the width and the height of the pillars, these are not influenced by the distance of the POV and so they are not related to the creation of different scenarios. The following Figure 33 describes how the values of the "Δ" are affected by the distance of the observer from the picture plane.

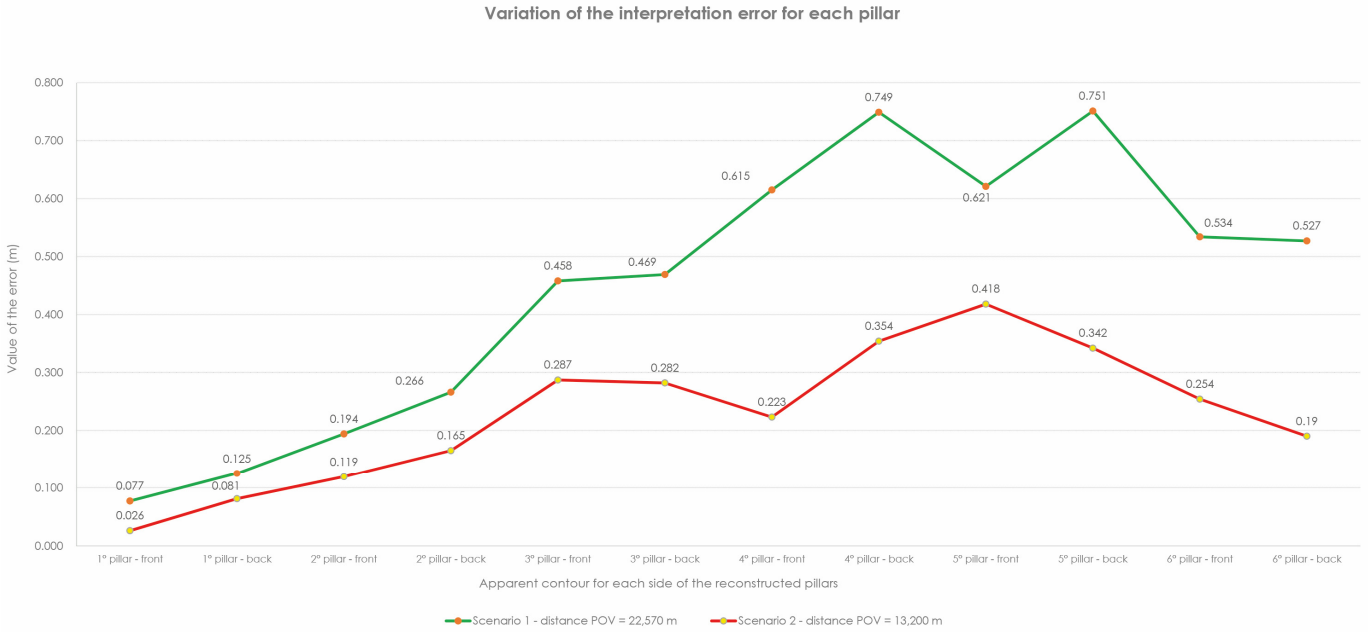


Figure 33. The comparison between two reconstruction scenarios of *Abbey in the Oakwood*. Here, we can notice the change of the value of the error in comparison with the distance of the observer from the picture plane.

4.2.4. Impact of the Error on the Dimensions of the First Scenario: Distance of the Observer from the Picture Plane of 22.58 m

One of the themes that is worth mentioning is the fact that the values of the error are related to the distance of the observer from the picture plane and this can be verified with the analysis of the previous graphs. In the analysis of the scenario, we will try to

understand at which extent the decision of the modeller on the apparent contour outline can affect the results of the mSeasurements and distances in the 3D environment.

As far as we need to analyse the two limit cases, in which the error fluctuates between the highest and the smallest value, we have to consider that the output of this analysis will give an idea of a range of values that are legitimate for the scenario that we are analysing. This kind of analysis will be carried out to understand the impact of the error on the ratio value to confirm the definition of the "densificated" space for the analysed scenario.

In this paragraph, we will analyse to what extent the error influences the following:

- Dimensions of the depth of the pillar;
- Dimensions of the depth of the intercolumation;
- The value of the ratio in the two extreme cases in the analysed scenario.

In the two extreme cases, we detected two denominations of the outlines in the two extreme cases. In particular, these denominations used the dimension of the pillar to distinguish between the two extreme cases, in particular when

- The denomination "external contour" is related to the scenario in which the depth of the pillar is maximized by "Δ/2" on both sides of the pillar (and, on the contrary, the intercolumniation is decreased by "Δ/2" on both sides)
- The denomination "internal contour" is related to the opposite scenario, in which the depth of the pillar is minimized by "Δ/2" on both sides of the pillar; on the contrary, in this case, the intercolumniation is increased by "Δ/2" on both sides.

The results of the analysis have been summarized in different graphs in order to ease the comparison between the different extreme cases in order to simplify the identification of the dimensional ranges that could be involved in the reconstruction of this scenario.

The size of the pillars indicates a gradual decrease as we proceed in depth. This type of trend is also confirmed by the definition of the pillar depth in the other two limit cases (this is to be taken quite for granted since the same amount is added and subtracted from all pillars—Figure 34).

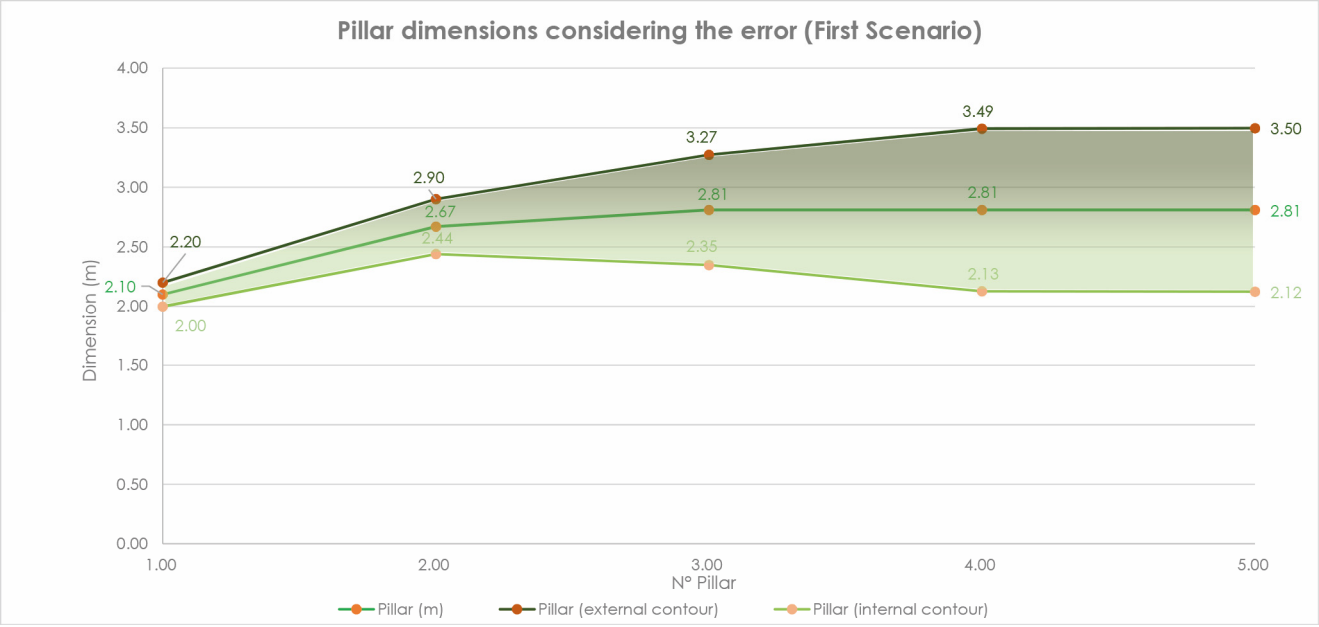


Figure 34. Trend of pillar width values in the various cases for the first analysed scenario.

In this case, the scenario as it was originally conceived was considered the average case and the limit cases were structured by adding and deducting half of Δ from the different

values, in this case, the depths of the pillars. Among the two limit cases, it is possible to recognise the range of values that can be detected for this scenario considering the retracing of the outline in this scenario.

It is also very interesting to analyse how the intercolumniation has been modified depending on the contour being considered, this can be seen in the graph below. It is important to emphasise that, for the intercolumnar space, it is not possible to subtract and add Δ for the pillars, since in the case of the intercolumniation, we will have to subtract and add two different values of Δ, relating to the two contiguous faces of the pillars that are divided by this intercolumniation. The range of values that the intercolumniation can assume are described in the Figure 35.

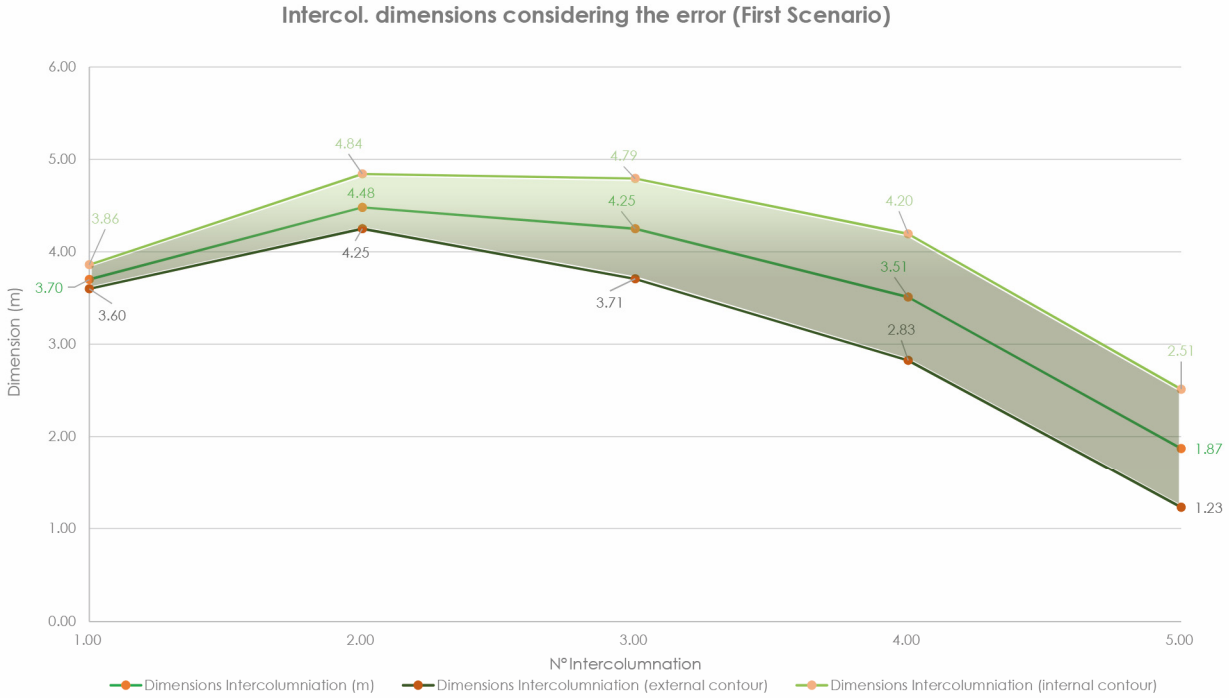


Figure 35. Trend of intercolumniation width values in the different cases for the analysed scenario.

In this particular case, we can see that the overall trend of the graph is downward, confirming the fact that the ratio value decreases as the intercolumnar distance decreases. Also in this case, it is possible to identify the range of values related to the interpretation of the apparent contour of the represented pillars. This range shows the different dimensions that the size of the pillar can assume depending on the tracing of the apparent contour. In Figure 36, it is possible to identify the range of values that the ratio can assume within the first reconstruction scenario of *Abbey in the Oakwood*.

This analysis was conceived as an afterthought to the reconstruction study as it helps us to understand in a practical way how much the modeller's decision affects the dimensional feature of the composition. This analysis was precisely conceived with the aim of helping us to understand in which range (with respect to the contour defined in the first reconstruction of the scenario) the dimensions of the elements could fall if the contour line was positioned differently from that used in the scenarios proposed in this article. As illustrated by the graphs above, the first analysed scenario of the painting *Abbey in the Oakwood* demonstrates that, even when accounting for the potential inaccuracy in the interpretation of the apparent contour, the trend of "densification" of architectural spatiality as defined by Friedrich is confirmed.

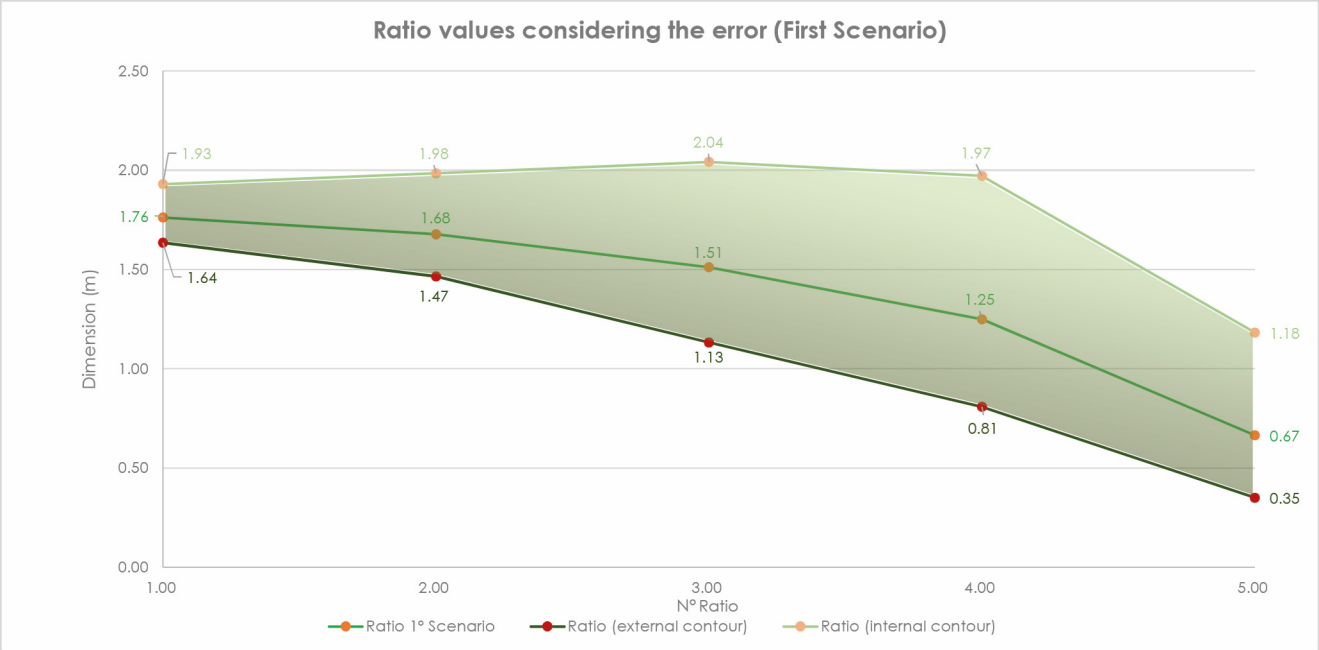


Figure 36. The probable values that the ratio can assume in relation to the drawing of the apparent contour for the first reconstruction scenario.

5. Conclusions

Findings and Future Outlooks

By analysing artworks with Eldena as a reference by Caspar David Friedrich, it becomes evident that the painter does not maintain a rigid perspective reconstruction of architectural space. This is supported by the reconstructions of the nave in the painting *The Eldena Abbey in Greifswald, 17 March 1836*, where the proportions of the different spatial ranges do not seem to follow any compositional pattern.

It should be noted that in the first analysed painting, *Abbey in the Oakwood*, the church of Eldena is used as a formal and aesthetic reference rather than a metrical one. The author does not reconstruct every element of the composition in detail, leaving out not only the formal details and the ornamental aspect but also the reconstruction of large parts of the building that existed at the time. In contrast, the other two representations exhibit a closer resemblance, albeit only in terms of aesthetics and morphology, to the nave of the church.

It is important to assess the contribution of Caspar David Friedrich's conception of spatiality to the spatial representation in his paintings. The proportional analysis of spatiality allows the comparison between Friedrich's spatialities and helps to understand how the author reworked Eldena's reference in a different way in the case of *Abbey in the Oakwood*.

The proportional composition of the spaces created by Friedrich in these three representations reveals the presence of three different arrangements in the representation of the central nave of the religious space.

- The progressive or partial 'densification' of the space of the nave, which refers to a gradual reduction in the intercolumniations (voids) of the nave in relation to the size of the pillars (solids). This is evidenced by a progressive ordered decrease in the ratio between these two dimensions. The phenomenon is observed in two artworks out of three.
    1. In Friedrich's *Abbey in the Oakwood*, the architectural spatiality is characterized by a "densification" of space, where the spans between represented objects progressively decrease as we move deeper into the scene. This is demonstrated

by the decreasing ratio values as we move from one interval to the next in different scenarios.

2. The drawing *The Eldena Abbey in Greifswald, 17 March 1836* reveals a partial 'densification' that extends to half of the nave, which can be identified precisely by its homogeneity in the architectural space created by Friedrich.

- The representation *The Eldena Abbey in Greifswald, 17 March 1836* exhibits opposite tendencies to the previously described 'densification' in a homogeneous portion of space. The elements positioned in the space are progressively distanced from one another, resulting in a new trend towards the 'rarefaction'. This is reflected in a progressive increase in the ratio between the intercolumniation and the thickness of the pillar. The representation of the religious space in this case is noteworthy due to the combination of two spatial compositions that coexist and merge homogeneously, and which, despite their variation, are only perceptible to the observer by analysing and reconstructing the space in 3D.
- It is important to note the third spatial arrangement in the second analysed painting, *Ruined Monastery of Eldena near Greifswald*. The composition of the nave space in this painting is irregular and does not follow any homogenous rule of composition. Although difficult to study and contextualise, this type of spatial composition should be mentioned and included in the study.

The spatial configurations presented here for the three pictures by Caspar David Friedrich can be identified with a proportional study such as the one proposed, and this type of study helps us to understand these spatial patterns, particularly at a quantitative level, by noting that there is a certain homogeneity with which these patterns are defined in space. This homogeneous presence indicates the possibility of identifying these spatial configurations, quantifying them and subsequently studying and comparing them within the different reconstructive scenarios.

The objective of this article is to analyse Friedrich's representation of architectural spatiality by considering homogeneous spatial patterns (as the three described before) using a proportional benchmark (the ratio between intercolumnar spaces and the width of the pillars). It is possible to apply these schemes to analyse other architectural representations in Romantic paintings or in other paintings by the Greifswald painter himself. This study's methodology could be extended to determine if these spatial configurations are unique to Caspar David Friedrich's depictions of Eldena Abbey, or if these patterns can be considered as a stylistic feature that was employed by Friedrich or other Romantic painters.

The application of the same methodology to identify compositional patterns in the representation of architectural spatiality in other paintings, by other authors or in different works, has significant implications. This methodology, which employs 3D modelling to facilitate a more agile approach, enables the analysis of cases of reconstruction in works of art where obtaining an objective metric reconstruction is not feasible. In such situations, it allows for an examination of the spatial representation created by the painter. By applying this methodology, aided by 3D modelling, to other paintings by Friedrich with other references related to the architectural motif, one could attempt to develop a more coherent theory of Friedrich's architectural representation of spaces with a regular and clearly defined structure (as in the analysed case, the nave of the Eldena church). Furthermore, the height of the modelled objects, which was mentioned in this study but not analysed in detail, is also sensitive to changes in the scenario related to the movement of the observation point on the painting. This issue could also be further analysed using this methodology. In conclusion, the objective of the proposed study is to examine a particular aspect of Friedrich's representation through the lens of quantitative-proportional analysis, employing digital tools such as 3D modelling. This approach aims to shed light on how the painter re-

elaborated the architectural motif and represented and reinterpreted it on canvas, utilising it as an expressive medium. The analysis of this artistic elaboration of an existing artefact through a quantitative-proportional approach allows for the precise definition of the degree of distance between the represented reference item and its interpretation by the painter.

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Conflicts of Interest: The author declares no conflicts of interest.

Notes

1 This artwork is referenced in the publication *Caspar David Friedrich—Die Zeichnungen* by C. Grummt. (Grummt 2011, vol. 1, p. 285, no. 289). This drawing can be visualised at the URL: https://www.staatsgalerie.de/de/collection/object/D0E78C8F4D3F79844680A6B905619A78. [accessed on: 4 December 2024].

2 This artwork is referenced in the publication *Caspar David Friedrich—Die Zeichnungen* by C. Grummt. (Grummt 2011, vol. 1, p. 363, no. 363). This painting can be visualised at the URL: https://fr.m.wikipedia.org/wiki/Fichier:Caspar_David_Friedrich_065.jpg. [accessed on: 4 December 2024].

3 This artwork is referenced in the publication *Caspar David Friedrich—Die Zeichnungen* by C. Grummt. (Grummt 2011, vol. 1, p. 368, no. 368). This drawing can be visualised at the URL: https://id.smb.museum/object/994731/der-winter---die-nacht---alter-und-tod-aus-dem-tageszeiten--und-lebensalterzyklus-von-1803. [accessed on: 4 December 2024].

4 This drawing has been shown in several publications concerning Caspar David Friedrich among them *Caspar David Friedrich: Zyklus, Zeit und Ewigkeit* on page 38, image no. 23 (Schmied 1999). The same representation can be observed in the publication *Caspar David Friedrich: Gefühl als Gesetz* on page 165, image no. 82 (Börsch-Supan 2008).

5 The name of this work is taken from the publication *Caspar David Friedrich—Die Zeichnungen* by C. Grummt(Grummt 2011) vol. 2, p. 883, no. 976. This painting is displayed in the following paragraphs. The history and naming of this work has been discussed in other publications, in particular in Schmitt's publication (1943) it is called *Eldena Abbey ruins towards the west* (*Ruine Eldena nach Westen)*.

6 In his article Scholl (Scholl 2007) on pp. 188–90,discusses the interpretation of the spatiality and arrangement of elements in the composition of the painting *Abtei im Eichenwald*. In particular, the author cites three articles that have been concerned with questioning the spatial composition of Friedrich's representation, namely (Zimmermann 2000) and the reflectographic study by (Timm 2004). The author takes up the ideas of these publications in order to formulate an interpretation of the role of liturgical space in Friedrich's painting.

7 This artwork is referenced to the publication *Caspar David Friedrich—Die Zeichnungen* by C. Grummt. (Grummt 2011, vol. 1, p. 364, no. 364). This drawing can be visualised at the URL: https://cdfriedrich.de/chronik/?_tags_filter=ruine&share-item=U2FsdGVkX1+K3h3Nlp5z5qn7ZzGEa8xKvvTJqHdfvMw= [accessed on: 4 December 2024].

8 In Schmitt's publication *Die Ruine Eldena im Werk von Caspar David Friedrich* (1943) (Schmitt 1943, pp. 16–25) the author describes the painting *Ruined Monastery of Eldena near Greifswald* naming it as *Eldena Abbey ruins towards the west* (*Ruine Eldena nach Westen)* and dates it to 1808 because of its similarities to the two versions of *The Winter* dated 1803 in Schmitt's publication.

9 This painting can be visualised at the URL: https://id.smb.museum/object/968249/abtei-im-eichwald [accessed on: 4 December 2024].

10 See Scholl (2007, p. 182) and concept of "*fiktiven Archäologie*" cited at p. 3 of this article.

11 In his article, Lissok describes how the academic governor of Eldena did not want any kind of intervention within the ruins until there was the intervention of Crown Prince Friedrich Wilhelm who took substantial care of the archaeological area of Eldena (Lissok 1997). Möbius, too, in the appendix to his publication "*Caspar David Friedrichs Gemälde „Abtei im Eichwald" und die frühe*

Wirkungsgeschichte der Ruine Eldena bei Greifswald" describes in detail the steps concerning the administrative management of the archaeological area in the 19th century (Möbius 1980, pp. 15–17).

12 This painting can be visualised at the URL: https://id.smb.museum/object/966456/klosterruine-eldena-bei-greifswald. [accessed on: 4 December 2024].

13 The definition of 'Critical Digital Model' can be explored further in the article: (Apollonio et al. 2021) A precise definition of Critical Digital Model is given on pages 5–6.

14 See note 12.

15 This watercolour can be visualised at the URL: https://cdfriedrich.de/chronik/ruine-der-abtei-eldena-bei-greifswald-von-osten/ [accessed on: 4 December 2024].

16 Architectural Survey by Balthasar can be consulted: C.G.W.: Balthasar, C. G. W. 1857. "Ruine Des Klosters Eldena."; URL: https://www.digitale-bibliothek-mv.de/viewer/toc/PPN1049685083/. [Accessed on: 7 December 2024].

17 See note 15.

18 See note 16.

19 See note 9.

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