AN INTERDISCIPLINARY LITERATURE SURVEY FOR DEGREES OF FREEDOM OF SPATIAL DESIGN

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ABSTRACT:
The reproduction of pictorial scenes in a digital space is a reconstructive practice that has become well established in the digital humanities. In this particular case, the applicable example is the reconstruction of the depicted sceneries by Caspar David Friedrich. This study aims to provide the opportunity to investigate stylistic aspects and sizing inconsistencies that are peculiar to the painter. The transition from 2D pictorial space to 3D reconstruction requires a separate methodological analysis concerning the criteria and categories through which this transition has to be investigated. As both of these types of representation contain common characteristics, the 'translation' between the two methodologies has to be delivered through shared categories. Grasping categories with which this process has to be explored requires a definition of Literature Survey that includes bibliographical sources related to 2D and 3D representation and their visualisation and perception. The analysis of the literature is based on a qualitative content analysis methodology. The process leads us to identify interdisciplinary categories defined through an inductive analysis of the sources and a hierarchical structure of main categories (Degrees of Freedom) and sub-categories.

KEY WORDS: Digital Humanities, Literature Survey, Degrees of Freedom, Caspar David Friedrich, Qualitative Content Analysis, Mayring.

1. INTRODUCTION

Looking at art history research, it is vital to consider how the use of digital technologies has led to the creation of a new way of conceiving the discipline, if we consider how the use of such methodologies has helped and enabled innovative possibilities of interacting with works of art. Therefore artworks and paintings have been repositioned as conjunctions between very disparate disciplines, that can be used to analyze, enhance and reconstruct the perception of the pictorial composition of Caspar David Friedrich.

In particular the 3D reconstruction of 2D representations in a digital space is a topic that the scholarship has repeatedly highlighted and studied to deliver the three-dimensional characterization of paintings through 3D modeling techniques. What needs to be defined are the categories through which the reconstruction of the depiction can be analyzed, communicated and perceived. Consequently, this study aims to:

- Understand according to which categories 3D modelling and 2D representations are able to communicate in the shift from one form of representation to the other.
- Understand how those Degrees of Freedom are conceived by different subjects and analyze the several standpoints about the same Degrees of Freedom.
- Identify, as an applicable example, in an interdisciplinary environment, which categories can be used to investigate the potential of reconstructing the peculiarities of Caspar David Friedrich’s paintings in three-dimensional digital space.

2. STATE OF THE ART

2.1 3D digital reconstruction of 2D representations

The relationship between digital technologies and art history does not only concern the aspect of the cataloguing and systematizing of iconographic material. Although if we focus on the study of literature on this issue, we find many studies on the employment of digital methodologies exploited for the development of databases with the aim of systematizing and retrieving useful representations for scholars in several scientific fields (Lang and Ommer, 2018). On the other hand, not many projects consider how digital technologies can be deployed for the definition of methods concerning the analysis of the perception of artworks not only as two-dimensional compositions but also as three-dimensional spatial environments (Lourakis, Alongi, Delouis, Lippi and Spadoni, 2007; Criminisi, Kemp and Zisserman, 2002).

2.2 3D reconstruction as an analytical tool.

In the methodological context of 3D modeling, it is useful to define the handling of a two-dimensional representation (such as a painting) through categories that are appropriate for 3D modeling as an analytical tool. For this purpose, it is essential to understand how the reconstruction of a depiction can be adapted to a tool such as 3D modeling by analyzing its peculiarities and limitations. This type of process in itself creates a conjunction between the investigated subject and the analytical methodology between the examined painting and the 3D modeling tool.

2.3 Degrees of Freedom

The aforementioned categories will henceforth be called “Degrees of Freedom”. It is a concept borrowed from disciplines that are far from art history, such as statistical and mathematical sciences. As far as those subjects are concerned, “Degrees of Freedom” are defined as “the number of independent parameters that are needed to specify the configuration of a system” (Daintith and Rennie, 2005, p. 60).

In order to define these Degrees of Freedom in our interdisciplinary research field, a Literature Survey within the disciplines concerning 2D representation methods and 3D reconstruction has been conducted.
2.4 Degrees of Freedom and Caspar David Friedrich

The subject of this study is the analysis of the depiction by Caspar David Friedrich, due to the fact that some of the aesthetic features of his composition can be easily analyzed through 3D modelling techniques. In particular, the German painter distinguishes himself by his elaboration and reconstruction of pictorial space aimed at defining a scene in which inconsistencies in the volumetric setting creates disorientation in the observer. (Grave, 2012)

An example, that defines these peculiarities as Degrees of Freedom that influenced Friedrich’s work, is the scaling and sizing of the instances of representation considering the perspectival structure created by the painter. This representational inconsistency, for instance in the painting The Sea of Ice, is precisely described by Johannes Grave in his monography on Friedrich. Grave mentions the relationship between the size of the objects in the representation and the perspective definition of the depiction as the painter’s denial of the aesthetic concept of the sublime in his work (Grave, 2012). Indeed, the presence of elements that disorient the observer, forcing them to a loss of spatial awareness, leads to a break between the painted scene and its observer, a materialized caesura on the pictorial surface.

Recognizing which aspects and formal categories lead to this detachment between the observer and the work of art and which Degrees of Freedom identify formal inconsistencies with the represented scene would reconcile the volumetric composition of the painter’s representation in digital space.

3. METHODOLOGY

3.1 Mayring’s qualitative content analysis method

In order to be considered scientifically reliable, the literature analysis must be handled with a structured and reproducible method based on a well-defined and streamlined methodology. The aforementioned methodology is Mayring’s qualitative content analysis method, which, through a critical analysis of the literature, lets us define the categories through the detailed analysis of an interdisciplinary bunch of sources. Through the different steps of Mayring’s methodology, certain categories were defined for the different paragraphs of the examined sources, the first coding operation was carried out on all the reviewed literature. Thereby, an immense number of codes with a very specific focus on the subject matter are obtained. These codes, closely linked to the discipline of the material they are derived from, are exceptionally hard to organize and to use as key categories for the analysis of the shift from 2D representation to 3D reconstruction. For this reason, the highly specific categories are then grouped together within overarching categories so that they can be systematized and clustered more effectively (Figure 1).

With this rigid and hierarchical coding mode, it is possible, by grouping the categories again, to ultimately obtain the Degrees of Freedom. These Degrees of Freedom, gained through this hierarchical and inductive method, are interdisciplinary. This is due to the fact that the specific categories subsumed within them belong to articles related to different disciplines. In Figure 1, the code headings for different paragraphs of the examined sources are highlighted in yellow. Blue codes indicate the subject categories that encompass the codes for the different paragraphs. Green codes describe the names of articles or chapters concerning the publication. In purple are the disciplines related to the different topics. Through this method of analyzing the literature, a hierarchical code system has been established, which allows to move from the general to the particular aspect of the subject.

3.2 Application of Mayring’s method to an Interdisciplinary Literature Survey

Mayring’s method for qualitative research applied to the field of Digital Art History and 3D reconstruction of two-dimensional representations has been employed with a systematic and hierarchical approach. In order to do so, the principles of Mayring’s methodology have been preserved as far as the quantitative approach and the inductive definition of categories were concerned. For this reason, a hierarchical system of categories was defined so that it would lead to a progressive definition of the Degrees of Freedom.

The core process of the literature survey is the process of coding. A code has been defined by Saldana in his Coding Manual for Qualitative Researchers as “a word, or a short phrase that symbolically assigns a summative salient essence capturing and/or evocative attribute for a portion of a language-based or visual data” (Saldana, 2009, p. 3). During the coding phase, the textual sources are analyzed by dividing them into paragraphs and applying a code to each of the identified paragraphs. From a practical point of view, considering all the 60 examined sources, the first coding operation was carried out on all the reviewed literature. Thereby, an immense number of codes with a very specific focus on the subject matter are obtained. These codes, closely linked to the discipline of the material they are derived from, are exceptionally hard to organize and to use as key categories for the analysis of the shift from 2D representation to 3D reconstruction. For this reason, the highly specific categories are then grouped together within overarching categories so that they can be systematized and clustered more effectively (Figure 1). With this rigid and hierarchical coding mode, it is possible, by grouping the categories again, to ultimately obtain the Degrees of Freedom. These Degrees of Freedom, gained through this hierarchical and inductive method, are interdisciplinary. This is due to the fact that the specific categories subsumed within them belong to articles related to different disciplines. In Figure 1, the code headings for different paragraphs of the examined sources are highlighted in yellow. Blue codes indicate the subject categories that encompass the codes for the different paragraphs. Green codes describe the names of articles or chapters concerning the publication. In purple are the disciplines related to the different topics. Through this method of analyzing the literature, a hierarchical code system has been established, which allows to move from the general to the particular aspect of the subject.

![Figure 1. Coding tree – Hierarchical structure of the detected codes.](https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-519-2023)
The structure of this Literature Survey for Degrees of Freedom research is defined through the collection of bibliographic materials that are heterogeneous both in type and subject matter. In the first part of the investigation, which will be presented in the first part of the abstract in order to understand whether these sources could be related to the search for categories that had a correlation with the 3D reconstruction of 2D representations (Table 2). The remaining 41 sources were analyzed through the Qualitative Content Analysis methodology.

### Table 1. Results of the preliminary Analysis of the Abstracts

<table>
<thead>
<tr>
<th>Sources</th>
<th>Number of sources</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluated Sources</td>
<td>55</td>
<td>91.7%</td>
</tr>
<tr>
<td>Rejected Sources</td>
<td>5</td>
<td>8.3%</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Table 2. Evaluated Sources after preliminary overall assessment

<table>
<thead>
<tr>
<th>Sources</th>
<th>Number of sources</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluated Sources</td>
<td>41</td>
<td>68.3%</td>
</tr>
<tr>
<td>Rejected Sources</td>
<td>19</td>
<td>31.7%</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100%</td>
</tr>
</tbody>
</table>

### 3.5 Topics

The topics covered and the number of articles per discipline are carefully balanced in order to keep the Literature Survey process as multidisciplinary as possible. The 41 articles were analyzed have also been clustered as to their topics in order to be able to understand the relevance of each discipline within the Literature Survey.

The examined materials are related to the topics that are described in the words cloud of the Figure 3.

![Figure 3. Examined Topics](image)

### 3.6 Keywords analysis

One of the most captivating aspects of the study concerns the difference between the various materials analyzed and how they can be compared as they all deal with the topic of representation, its visualisation and fruition. This leads, although the materials may be heterogeneous, to an overlap between the main topics of the different sources. The study of keywords is valuable to understand which specific themes are the most frequent within the analyzed set of sources. In the case of the proposed Literature Survey, the keyword study defines which specific topics were tackled in the selected set of sources. This type of study helps to emphasise, to the person conducting the study as well as to the person whose aim it is to evaluate it, which topics have been most frequently encountered. It, therefore, connects the identified Degrees of Freedom to specific technical topics discussed in the examined data.

The first step of this analysis is related to the qualitative literature research. In fact, for many of the examined articles, it

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This contribution has been peer-reviewed.

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was not possible to explicitly identify keywords given in the appropriate section of the publication. For this reason, it was necessary to proceed with the definition of keywords related to the source by cross-referencing the topics dealt with in the publication with the findings obtained within the qualitative analysis using Mayring’s method. Among the examined articles, 54% had the keywords explicitly mentioned in the article. In the remaining 46% for which the keywords were not specified, we used the aforementioned method.

<table>
<thead>
<tr>
<th>Keywords source</th>
<th>Number of sources</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified keywords in the source</td>
<td>22</td>
<td>54%</td>
</tr>
<tr>
<td>Deduced keywords from the content</td>
<td>19</td>
<td>46%</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3. Keywords specified in the sources and deduced through qualitative analysis.

The keywords identified are 123 in the different publications and Table 4 describes the frequency with which these describe the content of the different sources.

<table>
<thead>
<tr>
<th>Keywords</th>
<th>Number of repetitions</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>“3D Modeling”</td>
<td>5</td>
<td>2.56%</td>
</tr>
<tr>
<td>“Art Architectural History”</td>
<td>3</td>
<td>1.54%</td>
</tr>
<tr>
<td>“Digital Humanities”</td>
<td>6</td>
<td>3.08%</td>
</tr>
<tr>
<td>“Digital Cultural Heritage”</td>
<td>4</td>
<td>2.05%</td>
</tr>
<tr>
<td>“Architecture”</td>
<td>5</td>
<td>2.56%</td>
</tr>
<tr>
<td>“Art”</td>
<td>3</td>
<td>1.54%</td>
</tr>
<tr>
<td>“Single View Reconstruction”</td>
<td>7</td>
<td>3.59%</td>
</tr>
</tbody>
</table>

Table 4. Most mentioned keywords

The table shows the keywords that were mentioned at least three times in the several articles. From the table, it can be seen that the search for sources focused on one of the topics closest to the main area of the shift between two-dimensional and three-dimensional representations. This is why “Single-view reconstruction” appears as the most frequently occurring keyword in the examined articles. Likewise, the transition from pictorial representation to 3D modelling comes into the foreground (“Digital Humanities”, “3D Reconstruction”) since through the study of the articles relating to these terms, it is possible to define the Degrees of Freedom relating to the different representational methods in both Digital Humanities and 3D modelling.

These keywords were further analyzed and clustered to understand their typology and their field of research. These studies and categorizations pursue the objective of learning how Degrees of Freedom are composed and which disciplines have contributed to the definition of the identified categories in this literature survey.

1. Some of the mentioned keyword have been employed to retrieve those articles through several source browsers. Some examples of keywords that have been used as research terms are: “3D Modeling”, “3D Reconstruction”, “3D Reconstruction paintings”, “Creating models from images”, “design process”, “Design Degrees of Freedom” and others.

The sorting of the 123 keywords by typology is fundamental to comprehending how the established categories are made up through this methodology. In particular, some general clusters were defined. They can be described as follows:

- **Architectural keywords**: KW related to architectural design, 3D reconstruction of new design and architectural heritage, architectural survey etc. (e.g. “Architecture”, “Architectural survey”)
- Art historical keywords: KW related to Romantic Art, Caspar David Friedrich, Interpretation of art, Digital Art History etc. (e.g. “Art”, “Paintings”)
- Technical keywords: KW related to technical aspects of the specific context of the article’s discipline. Those aspects are related to technical concepts that are very specific for the article and they don’t belong to the two aforementioned categories. (e.g. “Camera calibration”, “Point cloud”)
- Interdisciplinary keywords: KW that don’t have any specific subject to which they either belong or are strictly related to. (e.g. “Topics”, “Digital”, “Challenges”)
- Keywords related to Data Management: KW related to Data Retrieval, Management of Digital Humanities Databases etc. (e.g. “Data mining”, “Data retrieval”).
- Methodology keywords: KW related to the specific methodologies employed in the different research processes and used in the several sources (e.g. “Qualitative”, “Survey methodology”).
- Specific keywords of the article: KW related to the select topics of the article. Some of them were not that easy to link to the topics of the detected Degrees of Freedom (e.g. “Etymology”, “Deep convolutional neural networks”).

<table>
<thead>
<tr>
<th>Subject of the Keywords</th>
<th>Number of Keywords</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D Reconstruction</td>
<td>30</td>
<td>24.39%</td>
</tr>
<tr>
<td>Visualisation</td>
<td>15</td>
<td>12.02%</td>
</tr>
<tr>
<td>Literature Survey &amp; Methodologies</td>
<td>19</td>
<td>15.43%</td>
</tr>
<tr>
<td>Art History</td>
<td>12</td>
<td>9.76%</td>
</tr>
<tr>
<td>Databases / Data Management</td>
<td>9</td>
<td>7.32%</td>
</tr>
<tr>
<td>Cultural Heritage</td>
<td>18</td>
<td>14.63%</td>
</tr>
<tr>
<td>Design</td>
<td>8</td>
<td>6.50%</td>
</tr>
<tr>
<td>Psychology</td>
<td>5</td>
<td>4.07%</td>
</tr>
<tr>
<td>Other Specific Subjects</td>
<td>7</td>
<td>5.69%</td>
</tr>
<tr>
<td>Total</td>
<td>123</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 5. Clustering of the keywords by subject.

Another necessary specification regarding 123 Keywords are the specific disciplines to which these keywords are associated.
In fact, defining the type and the frequency of the keywords is not sufficient to specifically understand how Degrees of Freedom can be composed. From this analysis, we deduce that most of the keywords are related to the main topic of 3D reconstruction and visualization/experience of the representation. (Table 5)

4. FINDINGS

The research mainly focused on understanding the meaning of each Degrees of Freedom in the discipline of the article in which it was identified. This type of approach helps to understand how different specific terms can be interpreted by different disciplines.

The interesting aspect of these categories is the way in which they are employed within an interdisciplinary methodological framework that considers their various facets and then defines these Degrees of Freedom in the 3D reconstruction environment with the idea of rendering them recognizable in the digital environment.

4.1 Results & Data

The research of Degrees of Freedom can lead to an understanding of how the same concepts (Degrees of Freedom) can be interpreted differently depending on the subject they are referring to. During the analysis of the materials by means of Mayring’s qualitative methodology, the MAXQDA software was highly beneficial since it has been developed to support coding operations. Through the coding strategies 9 Degrees of Freedom were identified. In particular, the coding process led to the identification of 1248 codes within the 41 analyzed articles. Moreover the grouping of codes with the same subject matter between different articles identified the Degrees of Freedom and how they are conceived by the different disciplines. Among the 1248 codes identified, 23 codes are excluded from the analysis because they do not contain information useful for research. Among the identified segments it is possible to specify the reference subjects. In fact, the acquired codes are divided as follows between the several analyzed disciplines: 82 codes related to Cultural Heritage & Digital Technologies, 39 to Gestalt Theory, 272 paragraphs related to Architecture and Planning, 416 paragraphs detected in Art History materials in relation to Caspar David Friedrich and Romantic Art, 331 paragraphs related to Digital Art History and 3D single view reconstruction, 80 paragraphs related to Virtual Reality and UX in VR and AR, and finally, 130 codes related to 3D reconstruction in architectural environments and for cultural heritage. From the results of the analysis of these paragraphs in the literature, it is possible for us to scrutinize the different examples of how these Degrees of Freedom are conceived by the various disciplines.

4.2 Degrees of Freedom: interdisciplinary definition

In order to provide example of what is meant by Degrees of Freedom, 9 Degrees of Freedom have been organized into a table that allows for comparison between different conception of the same Degrees of Freedom in multiple disciplines. This kind of Literature Survey process can be considered from many other points of view, and therefore the same Degrees of Freedom could also be examined through the lens of other disciplines. In order to provide an interdisciplinary definition of Degrees of Freedom, they have been systematized in a table. In this table paragraphs are gathered examples of codes derived from the qualitative content analysis to convey a particular idea of how that Degrees of Freedom could be defined by a precise topic area.

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architecture</th>
<th>Art History</th>
<th>Digital Art History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial and Perspective arrangements</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
<td><img src="image3" alt="Image" /></td>
</tr>
</tbody>
</table>

Table 6. Spatial and Perspective arrangements

Spatial and perspective arrangements. The standpoint of art history considers the handling of space as a scenic component for reconstruction of a depicted scene (Lourakis, Alongi, Delouis, Lippi and Spadoni, 2007). In 3D modelling, this Degree of Freedom is linked to the management of a view, which brings into play the observer’s field of view and the management parameters of a view in a 3D modeler.

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architecture</th>
<th>Art History</th>
<th>Digital Art History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conception of detail</td>
<td><img src="image4" alt="Image" /></td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
</tbody>
</table>

Table 7. Conception of detail

Conception of detail. As far as the fragment about architecture is concerned, the level of detail becomes a physical and management element of the project, even simply as a scale of representation of the project (Yaneva, 2005). In the passage related to art history, detail is an element that becomes strategic in the composition to attract the observer’s attention (Grave, 2012). In the fragment concerning Digital Art History, detail becomes a vital element to create an image retrieval system to search a database of images (Lang and Ommer, 2018). As far as 3D modelling is concerned, the level of detail of the model is linked to the purpose of the representation and to the scale of representation of the model. In particular Alkoven states that “the level of detail is strongly dependent on what purpose the computer model will serve. The distance from which the model is to be viewed is a determinant of how detailed the model must be” (Alkoven, 1991, p. 552).

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architecture</th>
<th>Art History</th>
<th>Digital Art History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationship in 2D compositions</td>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
<td><img src="image9" alt="Image" /></td>
</tr>
</tbody>
</table>

Table 8. Relationship in 2D compositions

Relationship between elements in 2D compositions. In the architectural conception of a plan the relationship between the elements is defined by the functioning of the floor plan and the
orientation of the building (Lobos and Donath, 2010). In the
passage on Art History, the idea is underlined that the painter
articulates the relationship in the artwork between the elements
on the painting’s surface (Grave, 2012). Concerning 3D
modeling the reconstruction of a view, and so the relationships
between his components, is achieved once is possible to
understand if we are able to place the elements with certainty
into the tridimensional digital space.

Table 9. Perception of the representation

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architectural</th>
<th>Art History</th>
<th>Digital Art History</th>
<th>Virtual / Augmented Reality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telling a story</td>
<td>Art History</td>
<td>Art History</td>
<td>Digital Art History</td>
<td>Virtual / Augmented Reality</td>
</tr>
</tbody>
</table>

Perception of the representation. In the passage about Art
History, perception is conceived as something that could be
guided and influenced by the choices of the painter (“as August
Wilhelm and Caroline Schlegel once wrote, the landscape
painter “teaches us to see. Droll, that we can so thoroughly
forget how to do that.” (Grave 2012, p. 222). In Digital Art
History, through the single-view reconstruction, the concept
is conveyed that, once a painting has been transformed into a
3D reconstruction of it, it acquires the feature of being investigated
from different perspectives and gives alternative perceptions
of the painting (Lourakis, Alongi, Delouis, Lippi and Spadoni,
2007). As far as Virtual and Augmented reality are concerned,
the aforementioned two visualization tools are able to
implement and strengthen the immersive experience of the
representation. In 3D modeling, those features are treated both
spatially (a 3D model can have a scope of 360 degrees) and
functionally. In fact, the modeler handles the perception of
the model in order to achieve the goal of showing particular views
of the represented object (Brusaporci, 2013).

Table 10. Scaling and relationship between volumes in the
composition

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architectural</th>
<th>Art History</th>
<th>Digital Art History</th>
<th>Virtual / Augmented Reality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telling a story</td>
<td>Architectural</td>
<td>Art History</td>
<td>Digital Art History</td>
<td>Virtual / Augmented Reality</td>
</tr>
</tbody>
</table>

Scaling and relationship between volumes in the
composition. In architectural design, scaling and relationship
between volumes plays a central role. It is the way in which
space is designed, how it is organized, and how it is perceived.
Scaling is a fundamental tool that allows architects to
manipulate the perception of space, creating a sense of
scale and proportion. It is a way to establish a hierarchy among
different elements and to create a balance and harmony in the
composition (Zweig, 2015).

Table 11. Representation of the architectural subject.

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architectural</th>
<th>Art History</th>
<th>Digital Art History</th>
<th>Virtual / Augmented Reality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telling a story</td>
<td>Architectural</td>
<td>Art History</td>
<td>Digital Art History</td>
<td>Virtual / Augmented Reality</td>
</tr>
</tbody>
</table>

Representing the architectural subject. This Degrees of
Freedom was defined thanks to the large amount of literature
that has been read on the subject and above all taking into
consideration the fact that this Degrees of Freedom was derived
from the work of Caspar David Friedrich. Indeed, the way
in which Friedrich treats architectural artefacts turns out to be
very expressive and unrestrained, always striving to privilege
the communicative aspect and to use architecture as a
communicative vehicle (Grave 2012). An architectural object
is rendered through the action of drawing and modelling and
the architect exploits those “tools” to understand and analyze
the result of his design. In particular, the tridimensional model
gives the opportunity to scope and communicate the project in
a more direct and streamlined way (Brusaporci, 2013). The
representation of an architectural complex is the last output
of an architectural survey campaign and it is one of the most vital
assumptions that a surveyor has to consider when approaching
the survey of a building. In fact, the measurement strategies
will be decisive to define the optimum representation methodology
to communicate the heritage of the building (Costantini,
Angelini and Caprino, 2007).
Visualization and Management of the Representation.

Visualization and representation management are both very general topics and are defined in very different ways across different subjects. In particular, this Degrees of Freedom differs from the perception of representation because it consists of the preparation of the material for use by the designer and the user to inspect and analyze spaces (Remondino and El-Hakim, 2006). Digital Art History has always discussed and considered the enriching factor of pictorial material through three-dimensional visualization (Drucker, 2013). Virtual reality acquired from a 3D reconstruction can be used to experience, analyze, study virtual scenarios of the reconstructed item. Visualization in the three-dimensional mode enhances the narrative quality of an architectural model of a cultural heritage building (Centofanti, Brusaporci and Lucchese, 2014).

The selected codes provide an explanation of how the same Degrees of Freedom can be defined differently depending on the discipline. The examples of codes have been compared in order to understand how the Degrees of Freedom can be interdisciplinarily defined in a three-dimensional space. To summarize: this explorative project, through the method of qualitative content analysis method, in the environment of the 2D representation and 3D reconstruction, arrived at the following two key products:

- The systematization of the interdisciplinary definition of the different Degrees of Freedom in the corresponding subject and the definition of the Degrees of Freedom in the 3D Modeling context.
- A definition of Degrees of Freedom through the analysis of sources based on subjects related to the 2D and 3D representation and to the depictional motifs of Caspar David Friedrich. They are now ready to be tested as evaluative categories to understand to which extent 3D Modeling can be an effective methodology for analyzing the depiction and the inconsistencies in the representation of Friedrich’s paintings.

Concerning this present study, it is significant to mention some limitations owing to the methodology employed. For instance the source retrieval method can lead to potential errors. In fact, the use of precise research items in the different source browsers can lead to find publications that are related to other topics and with other keywords defining the topic of the article.

5. CONCLUSION & FURTHER RESEARCH

This article describes an exploratory approach using Mayring’s qualitative research methodology to obtain categories for analyzing the transition from a two-dimensional to a three-dimensional representation. The derived categories, considering that the set of sources can be extended, can likewise be implemented and characterised in increasing detail given different facets. The most intriguing possibility that follows from this is the examination of such Degrees of Freedom within the digital space by comparing the acquired categories with the practical experience of modelling Caspar David Friedrich’s artworks. The dialectic defined in this way compares a theoretical approach based on an analysis of the literature, and a practical approach to understanding whether the categories

Table 13. Lighting.

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architecture</th>
<th>Art History</th>
<th>Architectural Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>The application of light and shadow is central to the modeling and rendering of the 3D space. The lighting can be used to enhance the mood and atmosphere of the scene. The designer can use light to create depth and dimensionality in the model. The lighting can also be used to convey religious meanings and to underline the presence of God in the depicted scene. Light modeling tool for the interior design or for the facade of the building can be easily used for diagnostic or historical reconstruction. The orientation of a building is concerned, it is important to mention that light in architectural design could be conceived as a design tool, for example, as far as the source retrieval method can lead to potential errors. In fact, the use of precise research items in the different source browsers can lead to find publications that are related to other topics and with other keywords defining the topic of the article.</td>
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</tbody>
</table>

Table 14. Visualization and management of the Representation.

<table>
<thead>
<tr>
<th>Freedom Degree</th>
<th>Architecture</th>
<th>Art History</th>
<th>Architectural Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualization and Management of the Representation</td>
<td>The modeler can use light and shadow to enhance the atmosphere and mood of the scene. The lighting can be used to create a sense of depth and dimensionality in the model. The designer can use light to convey religious meanings and to underline the presence of God in the depicted scene. Light modeling tool for the interior design or for the facade of the building can be easily used for diagnostic or historical reconstruction. The orientation of a building is concerned, it is important to mention that light in architectural design could be conceived as a design tool, for example, as far as the source retrieval method can lead to potential errors. In fact, the use of precise research items in the different source browsers can lead to find publications that are related to other topics and with other keywords defining the topic of the article.</td>
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obtained with the first method can be verified, questioned, or extended.

ACKNOWLEDGEMENTS. Thanks are due to the DFG – Research Training Group ‘Modell Romantik’ for funding and supporting the research.

REFERENCES


