



**TECHNISCHE  
UNIVERSITÄT  
DRESDEN**



**Computer Graphics  
and Visualization**

Faculty of Computer Science

Institute of Software and Multimedia Technology  
Chair of Computer Graphics and Visualization

Bachelor Thesis

# **Occlusion Avoidance for Immersive Inspection of 3D Cell Complexes and Cell Surfaces**

Joris Grau

Born on: 6th January 2001 in Dresden  
Matriculation number: 4901060

4th November 2022

First referee

**Prof. Dr. Stefan Gumhold**

Second referee

**2nd Referee**

Supervisor

**Supervisor I**





## Task for the preparation of a Bachelor Thesis

Course: Computer Science  
Name: Joris Grau  
Matriculation number: 4901060  
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Title: Occlusion Avoidance for Immersive Inspection of 3D Cell Complexes and Cell Surfaces

## Objectives of work

Momentan ist das besagte Thema in aller Munde. Insbesondere wird es gerade in vielen – wenn nicht sogar in allen – Medien diskutiert. Es ist momentan noch nicht abzusehen, ob und wann sich diese Situation ändert. Eine kurzfristige Verlagerung aus dem Fokus der Öffentlichkeit wird nicht erwartet. Als Ziel dieser Arbeit soll identifiziert werden, warum das Thema gerade so omnipräsent ist und wie dieser Effekt abgeschwächt werden könnte. Zusätzlich sind Methoden zu entwickeln, mit denen sich ein ähnlicher Vorgang zukünftig vermeiden lässt.

## Focus of work

- Recherche & Analyse
- Entwicklung eines Konzeptes & Anwendung der entwickelten Methodik
- Dokumentation und grafische Aufbereitung der Ergebnisse

First referee: Prof. Dr. Stefan Gumhold  
Second referee: 2nd Referee  
Supervisor: Supervisor I  
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Prof. Dr. Stefan Gumhold  
Supervising professor



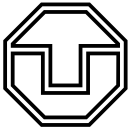
# Statement of authorship

I hereby certify that I have authored this document entitled *Occlusion Avoidance for Immersive Inspection of 3D Cell Complexes and Cell Surfaces* independently and without undue assistance from third parties. No other than the resources and references indicated in this document have been used. I have marked both literal and accordingly adopted quotations as such. There were no additional persons involved in the intellectual preparation of the present document. I am aware that violations of this declaration may lead to subsequent withdrawal of the academic degree.

Dresden, 4th November 2022

Joris Grau





## Abstract

This is an abstract. The abstract is written after finishing the work and should give an overview about the motivation, used methods, as well as the results. It is here to inform the reader about the core topics of the work and if it is relevant to his research. The abstract stands for itself and uses no components of the rest of the work. In consequence, there are no references nor citations used here. It should be around 100 to 250 words. There should always be an english version of your abstract, regardless of the language the work is actually written in.

## Zusammenfassung

Das ist eine Zusammenfassung. Die Zusammenfassung wird geschrieben, nachdem die Arbeit fertiggestellt ist und sollte einen Überblick über Motivation, Methoden und die Ergebnisse geben. Die Zusammenfassung informiert den Leser über die Kernthemen der Arbeit und ob die Arbeit für seine Forschung relevant ist. Die Zusammenfassung ist von der Arbeit entkoppelt und verwendet keine anderen Komponenten der Arbeit. In der Folge werden hier keine Referenzen oder Zitierungen genutzt. Sie sollte zwischen 100 und 250 Worten umfassen. Unabhängig von der Sprache, in der die Arbeit verfasst wurde, sollte es immer eine englische Version der Zusammenfassung geben.





# Contents

Abstract . . . . .	VII
Zusammenfassung . . . . .	VII
Symbols and Acronyms . . . . .	XI
1 Introduction . . . . .	1
2 Background . . . . .	3
3 Related Work . . . . .	5
4 Methods and Implementation . . . . .	7
5 Results . . . . .	9
6 Conclusion and Further Work . . . . .	11
A Appendix I . . . . .	19
B Appendix II . . . . .	21



# Symbols and Acronyms

<b>WYSIWYG</b>	What You See Is What You Get	<b>GPU</b>	Graphics Processing Unit
<b>CGV lab</b>	Chair of Computer Graphics and Visualization		



# 1 Introduction

The human brain consists of 86 billion neurons. Even if one wanted to pick out, visualize and examine just a tiny fraction of these, it would be very difficult to make any meaningful conclusions, as the sheer volume of data prevents close inspection. Nevertheless, correct and precise analysis of datasets is a cornerstone of any research, but this is often challenging and error-prone, especially when the complexity and size of the dataset increases. A common problem with such large data sets is that the data you are trying to examine is obscured and blocked by other data, this is especially the case with three dimensional data sets and is called occlusion. Therefore, it is important to develop methods and programs that filter or transform data sets and allow a closer look at individual parts of the data set as well as their context. There are many different techniques to avoid and reduce occlusion. These methods can roughly be divided into two types: hiding unimportant data and transforming the data set so that occlusion is avoided. For example, it is possible to use clipping planes to hide foreground data. A common problem with using them is that the context of the data is difficult to recognize, because only a part of the whole is shown. To reduce this, the position of individual data can be changed so that no more occlusion occurs, but all data is still displayed. One way of transforming the data set is through the use of exploded views. Here, individual parts of a model or data set are pulled apart in such a way that each part of interest can be viewed in detail and the original composition of the data set remains recognizable.

**The goal** of this work is to examine and compare different methods for generating such exploded views for cell complexes. Furthermore, it will be tested which of these methods are suitable for inspection in virtual reality (VR) and what new possibilities and difficulties this innovative environment brings. Since the immersive visualization of such models in virtual reality and its intuitive interaction creates completely new possibilities for exploded views, it is important to find out which techniques are effective and which established methods are not suitable. To do this, an analysis of the state of research and a classification of the different methods will be developed, followed by a prototypical implementation of some selected techniques for exploded views and a comparison of their effectiveness in the VR. For this purpose, a data set of a cell complex is available which is visualized and transformed. This dataset was simulated and it describes the change of the cell complex over a defined period of time. Therefore it is necessary that the visualization and the explosion view can also

show the temporal change of the individual cells of the cell complex. Furthermore, different interaction types are to be tested.

In order to achieve this, the work is divided into **the following structure**. First, general terminologies and problems of exploded views are explained, then a thorough literature analysis takes place on related works and their solution approaches on the subject of occlusion avoidance of dynamic and static data sets. It continues with a more precise classification of the topic and the solution approaches that are pursued in this work. Then the results are shown and explained in a subsequent discussion. At the end there is a summary of the work as well as further approaches that could be explored in a future work.

If you look at traditional hand-drawn explosion views, you can see that both the explosion direction in which the parts are moved and the spacing of the parts must be well chosen. A number of other properties are also helpful for exploded views that are as meaningful as possible.

## 2 Background

When examining complex data sets or models, it is often important to understand the composition of the individual components and their order of assembly. This is especially the case for technical and biological models, where the order of composition defines the function. A problem that often arises is how to inspect the inner parts of such a model without breaking the compositional order. One possibility is to use filters and to cut away the frontal parts, but this is done at the expense of the overview and can make it difficult for the viewer to correctly identify the position of the part in the object. To avoid this, this work focuses on exploded views, as they offer the possibility to reveal internal parts of complex models while preserving their position in relation to other parts. Furthermore, they offer good interactive possibilities, which can also be transferred to the interaction in virtual reality.

Exploded views are drawings or information graphics that pull apart a complicated object as if it were blown up in a controlled manner. The individual parts are then spatially separated so that their position inside the object or model becomes visible. Often the projection of the object takes place in a planar view from the side or from slightly above. This type of representation has a long history and can be found in many technical drawings, as the individual parts can be named and the order of assembly becomes clearly recognizable.

Looking at traditional hand-drawn explosion views, it becomes apparent that both the explosion direction in which the parts are moved and the spacing between the parts must be well chosen. In order to create the most informative explosion views, Li et al. describe five additional desirable conventions in their paper.

- **Blocking constraints:** Parts should be translated so that they do not pass other parts, this is to show the viewer how the components fit together and indicate their relative position.
- **Visibility:** The spacing of all parts should be chosen so that each part of interest is visible.
- **Compactness:** Parts should be moved as little as possible from their original position to facilitate the viewer's mental reconstruction.
- **Canonical explosion directions:** Most objects have a canonical direction, i.e. an axis in which the object can best be aligned after the explosion. This is determined by various

object-specific properties. In order to reduce the visual clutter, only a few of these axes should be chosen, otherwise the viewer will have difficulty recognizing the original composition.

- **Part hierarchy:** Complex models are sometimes divided into different exploded views and axes, this can illustrate the composition of smaller parts of the object.

If internal parts of an object are completely enclosed, it is necessary to either remove or cut open the outer part. According to Li et al., it should be ensured that when the outer object is cut, the distance with which the outer parts are pulled apart is kept as minimal as possible, whilst still leaving the inner parts visible. In such cases it is also common to hide the outer parts to reveal the inner composition.

A distinctive feature which is relevant for this work are the utilized data sets. They have been generated using the program *Morpheus* which is being developed at the TU Dresden. *Morpheus* can be used to simulate and visualize the temporal changes of cell complexes and their evolution. The datasets thus represent a biological model in which there is no fixed order of composition and the individual parts may change their position and size over time.



## 3 Related Work

Describing the research field with relevant works on the same or similar issues.



## 4 Methods and Implementation



## 5 Results



## **6 Conclusion and Further Work**





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## List of Figures



## List of Tables



# A Appendix I

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.





## B Appendix II

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.