2 Related Work

Visualization domains that are related to our work can be categorized into molecular visualization, and occlusion management. We will focus mainly on occlusion management as this is also the focus of this paper. //After we present a short historic overview of the development of cutaway techniques we discuss recent related work.

2.1 Occlusion Management

Structure / Order

Cutaways (object of interest)

* Cutaway first introduced by steve finer in the 80… [todo]
* diepstraten? Rules for section views [todo]  
  2002: transparency in interactive illustrative vis  
  2003: interactive cutaway illustrations
* smart visibility
* viola phd
* importance driven volume rendering:
* burns
* krüger?
* Li
* Lawonn
* Baer, Preim: perceptual eval of ghosted views

Transferfunctions ()

* Correa – visibility histograms
* Ruiz – automatic TF

Text

Cutaway and ghosting techniques were first introduced by Finer & Seligmann in 1992 as an automated approach for generating illustrations that consider the occlusion of user defined objects. The authors introduced a set of algorithms that automatically identify and handle potentially obscuring objects which - enabled due to the introduction of the z-buffer to then modern graphics hardware.

In 2002, Diepstraten et al [diepstraten2002] picked up the technique again and defined a set of rules for computer-based rendering of technical illustrations to achieve a view-dependent transparency model that mimics the ghosting techniques of technical illustrations. They later extended these rules for interactive cutaway illustrations [diepstraten2003].

In 2005, Viola et al. coined the term “smart visibility” as a collective term for cut-away views, ghosted views, and exploded views - to describe expressive visualization techniques that smartly uncover the most important features of the displayed data.

[conclusion of this sub-section]  
since the obstructing information is cut away - most modern approaches have something in common in alleviating this inherent shortcoming: they try to preserve the structures that have been cut, in some way or another.

due to the data type & how we handle it, our approach is fundamentally different from existing cutaway approaches. in our approach, (partial) occlusion of individual objects is not an issues as the data does not contain large singular entities such as polygonal or segmented volumetric objects where each single one has a semantic meaning.

instead there are thousands of instances of a couple of dozens molecule types. objects are never partially cut - just removed or not. not based on a density function as in TFs in volume rendering or on specific objects of interest - but based the combination of those two aspects: clipping object(s) & a visibility function/histogram for each molecule type.

still, principles from existing cutaway algorithms can also be applied to our approach.

2.2 Molecular Visualization

//TODO

3. Overview

3.1 Data

our data according to the Elmqvist taxonomy:

* high object density
* high object interaction:
  + high proximity: hundreds of thousands (millions?) of molecules of dozens of different types, densly packed
  + high enclosure: some molecules form structures that enclose other types of molecules, e.g., nucleus, cell membrane
* object complexity:
  + low, from a cutting perspective: since objects are either entirely cut or not
  + high, from a visual perspective: they are complex structures that consist of dozens or hundreds of atoms
  + partial occlusion of individual molecules is not an issue since there typically are many instances of each type visible at the same time

X Discussion

X.1 Elmqvist’s taxonomy for occlusion management

elmqvist et al described a taxonomy of occlusion management techniques. the techniques can be grouped into five different design patterns that support different tasks and are suitable for different data types. the visibility equalizer (VE) falls into the virtual x-ray technique that applies transparency or object removal - which is the most suitable method for the dense molecular data that we are dealing.

virtual x-ray techniques such as cutaways make discovery trivial & facilitate access. They have very high disambiguation strength –which means they can handle dense data (high proximity) with enclosement, containment, .. they support view dependent and static approaches to occlusion handling.

inherent downsides:

* weakens occlusion depth cues => decrease in depth perception, makes spatial relation difficult. However, this can be tackled with special cutting conventions & illumination / shading. And also other special approaches: [=> refer to fuzziness section]
* transparency (ghosting): yields additional visual complexity, more cognitive load  
  [=> mention ghosting/contours if we implement them]

the user task according to the taxonomy: all three tasks are somewhat relevant in our context

* target discovery: know where specific molecule types lie in the cell
* target access: retrieve graphically encoded info: not on a single instance level - however on a per-type level - how big is the volume of the type
* spatial relation: which types are enclosed by which, where do they lie, how is the distribution?

other techniques such as multiple view, tourplanners, volumetric probes, and projection distorter would not be well suited to gain the desired insight into the dense molecular cell data

* multiple viewports, tour planners: the cell data is dense => multiple view ports would still suffer from occlusion. Cutaways &transparency necessary acts as a window into this dense data
* probes, projection distortion: we do not want to distort the data since the organic / anatomical / cellular structure needs to be preserved

X.2

Related techniques can be grouped into techniques that..

* OOI based vs TF
* polygon vs volume representation
* automated vs interactive specification of the cutaway