Global Illumination for Fun and Profit breddh

Roy G. Biv, Ed Grimley, *Member, IEEE*, and Martha Stewart

Fig. 1. In the Clouds: Vancouver from Cypress Mountain. Note that the teaser may not be wider than the abstract block.

Abstract— Occlusion is an issue in volumetric datasets visualization as it prevents direct visualization of the region of interest. To address this problem, many techniques have been developed such as transfer functions, volume segmentation or view distortion. Even if these techniques have proven their efficiency, there is still room for improvement to better support the understanding of objects' vicinity. However, most existing Focus+Context fail to solve partial occlusion int datasets where the target and the occluder are very similar density-wise. For these reasons, we investigated a new technique which maintains the general structure of the investigated volumetric dataset while addressing occlusion issues. As such, we propose a focus+context technique. The user interactively defines an area of interest where an occluded region or object is partially visible. Then our lens starts to operate and pushes at its border occluding objects (i.e. local deformation), thus revealing hidden parts of the volumetric data. Next, the lens is modified with an extended field of view (fish-eye deformation) to better see the vicinity of the selected region. Finally, the user can freely explore the surroundings for the area under investigation within this lens. To develop this technique, we used a GPU accelerated ray-casting framework with a set of interactive tools to ease volumetric data exploration and real-time manipulation. We illustrated the efficiency of this technique thanks to three examples where the occlusion issue is addressed: 3D scanned luggage exploration, aircraft trajectories, and streamlines..

Index Terms—Radiosity, global illumination, constant time

1 Introduction

Thanks to various rendering techniques, volumetric data can be displayed in many different fields (engineering, material sciences, medical imaging, etc.). Direct volume rendering techniques or isosurfaces techniques render these volumes into graphical representations in order to allow their exploration. In volume rendering, occlusion management is a challenge. As such, in 3d representations of volumes, some areas or objects (subsets) can be partially or fully hidden by others because of their locations.

Global techniques such as transfer functions, segmentation, and selection/clipping are used to remove occlusion in the entire volume. Therefore, they are a good way to reduce occlusion and make visible interesting features. However, it is still difficult to create a good transfer function/segmentation especially when the data are heterogeneous. In fact, designing a good transfer function depends heavily on the type of dataset and on the user's purpose. For instance, in the field of baggage inspection, the variation of densities prevents to create a unique transfer function for each baggage. In contrast, it is easier to design a good transfer function for a system dedicated to visualizing the same type of datasets (brain CT scans, bone tissues, etc.).

Many studies propose different tools and interaction techniques to by-pass occlusion issues in 3D environments such as lenses, deformations [**?**], augmented reality, etc. Lenses, which are flexible lightweight tools that enable local and temporary modifications of the visualization, are suitable to deal with occlusion while keeping information about the global context. This is a good local solution for occlusion problems and an interesting way to keep the user aware of the global meaning of the dataset. Thus, while most lenses in volume rendering are used to magnify a volume subset [**?**], we propose a focus+context (F+C) lens that combines a distortion technique which pushes aside the occluding objects, and a fish-eye field of view in order to provide a better perspective on partially occluded items of interest in the volumes.

Furthermore, performances are still a challenge in volume rendering systems. In fact, depending on the size of the dataset and also the resolution of the resulting produced image: the rendering process can be very slow. Some optimization strategies such as empty space skipping [**?**], early ray termination [**?**], multiple and adaptive resolutions allow to speed up the rendering process by increasing the frame rate. With

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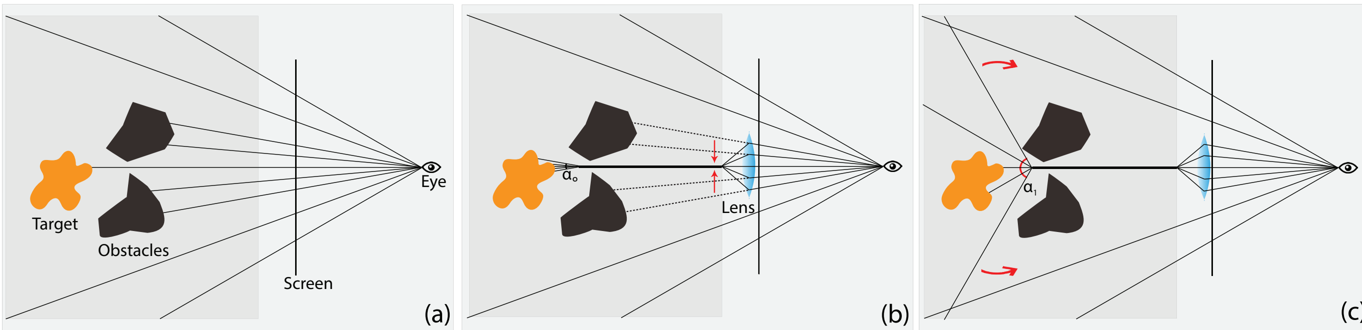

Fig. 2. The mechanism of the obstruction-free fish-eye lens. (a) The classic ray-casting where an interesting feature is partially hidden by other items in front of it. (b) The first main step: The lens makes converge the rays to avoid the obstacles. Once they are close to the target, the rays follow again their initial trajectory (with the initial angle) of view α_0. Only a small part of the target is visible and magnified. (c) The target become visible by increasing the angle of view to $\alpha_1 \in [120, 180]$.

the advent of CUDA as a higher-level GPU programming language, CUDA-based ray-casters were introduced [**?**]. So, in order to support our focus+context interactive lens, our volume visualization system relies on a CUDA-based ray-casting algorithm [**?**]. This framework enables volumetric datasets visualization and offers a set of interactive tools including our lens for the purpose of easing the exploration and the manipulation of the data.

The structure of this paper is as follows. Section 2 presents related work in the areas of ray-casting, occlusion management, lenses and deformations. Section 3 describes the principle of our lens. Section 4 presents a method to convert vector datasets into a volume. Section 5 illustrates our lens technique with 3 scenarios. Section 6 discusses the presented technique. Finally, section 7 concludes the paper.

2 Using the Style Template

- If you receive compilation errors along the lines of "`Package ifpdf Error: Name clash, \ifpdf is already defined`" then please add a new line "`\let\ifpdf\relax`" right after the "`\documentclass[journal]{vgtc}`" call. Note that your error is due to packages you use that define "`\ifpdf`" which is obsolete (the result is that `\ifpdf` is defined twice); these packages should be changed to use ifpdf package instead.

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- For adding hyperlinks and DOIs to the list of references, you can use "`\bibliographystyle{abbrv-doi-hyperref-narrow}`" (instead of "`\bibliographystyle{abbrv}`"). It uses the doi and url fields in a bibTeX entry and turns the entire reference into a link, giving priority to the doi. The doi can be entered with or without the "`http://dx.doi.org/`" url part. See the examples in the bibTeX file and the bibliography at the end of this template.

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  Note 2: the "`-narrow`" versions of the bibliography style use the font "PTSansNarrow-TLF" for typesetting the DOIs in a compact way. This font needs to be available on your LaTeX system. It is part of the "paratype" package, and many distributions (such as MikTeX) have it automatically installed. If you do not have this package yet and want to use a "`-narrow`" bibliography style then use your LaTeX system's package installer to add it. If this is not possible you can also revert to the respective bibliography styles without the "`-narrow`" in the file name.

  DVI-based processes to compile the template apparently cannot handle the different font so, by default, the template file uses the `abbrv-doi` bibliography style but the compiled PDF shows you the effect of the `abbrv-doi-hyperref-narrow` style.

3 Bibliography Instructions

- Sort all bibliographic entries alphabetically but the last name of the first author. This LaTeX/bibTeX template takes care of this sorting automatically.

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- Articles in journal—items to include:

  - author names

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- month of publication as variable name (i. e., {jan} for January, etc.; month ranges using {jan #{/}# feb} or {jan #{--}# feb})

- use journal names in proper style: correct: "IEEE Transactions on Visualization and Computer Graphics", incorrect: "Visualization and Computer Graphics, IEEE Transactions on"

- Papers in proceedings—items to include:
  - author names
  - title
  - abbreviated proceedings name: e. g., "Proc.\ CONF_ACRONYNM" without the year; example: "Proc.\ CHI", "Proc.\ 3DUI", "Proc.\ Eurographics", "Proc.\ EuroVis"
  - year
  - publisher
  - town with country of publisher (the town can be abbreviated for well-known towns such as New York or Berlin)

- article/paper title convention: refrain from using curly brackets, except for acronyms/proper names/words following dashes/question marks etc.; example:
  - paper "Marching Cubes: A High Resolution 3D Surface Construction Algorithm"
  - should be entered as "{M}arching {C}ubes: A High Resolution {3D} Surface Construction Algorithm" or "{M}arching {C}ubes: A high resolution {3D} surface construction algorithm"
  - will be typeset as "Marching Cubes: A high resolution 3D surface construction algorithm"

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  - DOI can be entered in the DOI field as plain DOI number or as DOI url; alternative: a url in the URL field
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4 Example Section

You can use the margins for comments while editing the submission, but please remove the marginpar comments for submission.

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[1] The algorithm behind Marching Cubes [?] had already been described by Wyvill et al. [?] a year earlier.

[2] Footnotes appear at the bottom of the column.

Table 1. VIS/VisWeek accepted/presented papers: 1990–2016.

year	Vis/SciVis	SciVis conf	InfoVis	VAST	VAST conf	TVCG @ VIS	CG&A @ VIS	VIS/VisWeek incl. TVCG/CG&A	VIS/VisWeek w/o TVCG/CG&A
2016	30		37	33	15	23	10	148	115
2015	33	9	38	33	14	17	15	159	127
2014	34		45	33	21	20		153	133
2013	31		38	32		20		121	101
2012	42		44	30		23		139	116
2011	49		44	26		20		139	119
2010	48		35	26				109	109
2009	54		37	26				117	117
2008	50		28	21				99	99
2007	56		27	24				107	107
2006	63		24	26				113	113
2005	88		31					119	119
2004	70		27					97	97
2003	74		29					103	103
2002	78		23					101	101
2001	74		22					96	96
2000	73		20					93	93
1999	69		19					88	88
1998	72		18					90	90
1997	72		16					88	88
1996	65		12					77	77
1995	56		18					74	74
1994	53							53	53
1993	55							55	55
1992	53							53	53
1991	50							50	50
1990	53							53	53
sum	**1545**	**9**	**632**	**310**	**50**	**123**	**25**	**2694**	**2546**

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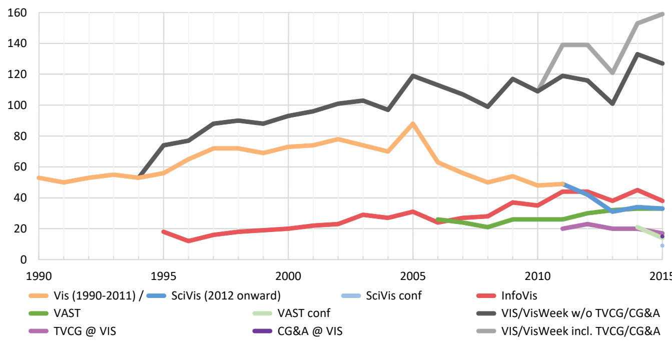

Fig. 3. A visualization of the 1990–2015 data from Table 1. The image is from [**?**] and is in the public domain.

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6 Conclusion

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Acknowledgments

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