Global Illumination for Fun and Profit

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

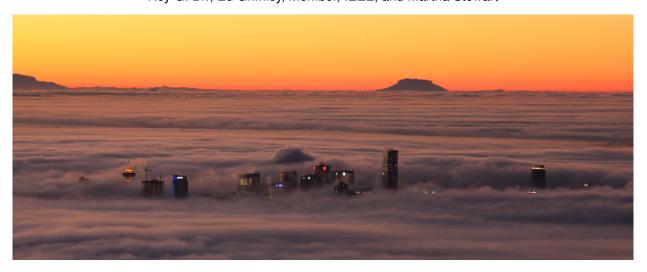


Fig. 1. In the Clouds: Vancouver from Cypress Mountain. Note that the teaser may not be wider than the abstract block.

Abstract—Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi. Lorem ipsum dolor sit amet, consectetuer adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat. Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi.

Index Terms—Radiosity, global illumination, constant time

1 Introduction

This template is for papers of VGTC-sponsored conferences such as IEEE VIS, IEEE VR, and ISMAR which are published as special issues of TVCG. The template does not contain the respective dates of the conference/journal issue, these will be entered by IEEE as part of the publication production process. Therefore, please leave the copyright statement at the bottom-left of this first page untouched.

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 Note that your error is due to packages you use that define "\ifpdf" which is obsolete (the result is that \ifpdf is defined twice); these packages should be changed to use ifpdf package instead.
- Note that each author's affiliations have to be provided in the author footer on the bottom-left corner of the first page. It is
- Roy G. Biv is with Starbucks Research. E-mail: roy.g.biv@aol.com.
- $\bullet \ \ \textit{Ed Grimley is with Grimley Widgets, Inc..} \ \textit{E-mail: ed.grimley} @aol.com.$
- Martha Stewart is with Martha Stewart Enterprises at Microsoft Research.
 E-mail: martha.stewart@marthastewart.com.

Manuscript received xx xxx. 201x; accepted xx xxx. 201x. Date of Publication xx xxx. 201x; date of current version xx xxx. 201x. For information on obtaining reprints of this article, please send e-mail to: reprints@ieee.org. Digital Object Identifier: xx.xxxx/TVCG.201x.xxxxxxx

permitted to merge two or more people from the same institution as long as they are shown in the same order as in the overall author sequence on the top of the first page. For example, if authors A, B, C, and D are from institutions 1, 2, 1, and 2, respectively, then it is ok to use 2 bullets as follows:

- A and C are with Institution 1. E-mail: {a | c}@i1.com.
- B and D are with Institution 2. E-mail: $\{b \mid d\}$ @i2.org.
- The style uses the hyperref package, thus turns references into internal links. We thus recommend to make use of the "\autoref{reference}" call (instead of "Figure"\ref{reference}" or similar) since "\autoref{reference}" turns the entire reference into an internal link, not just the number. Examples: Fig. 2 and Table 1.
- The style automatically looks for image files with the correct extension (eps for regular LATEX; pdf, png, and jpg for pdfLATEX), in a set of given subfolders (figures/, pictures/, images/). It is thus sufficient to use "\includegraphics{CypressView}" (instead of "\includegraphics{pictures/CypressView.jpg}").
- 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.

Note 1: occasionally (for some LATEX distributions) this hyper-linked bibTEX style may lead to compilation errors ("pdfendlink ended up in different nesting level ...") if a reference entry is broken across two pages (due to a bug in hyperref). In this case make sure you have the latest version of the hyperref package (i.e., update your LATEX installation/packages) or, alternatively, revert back "\bibliographystyle{abbrv-doi-narrow}" (at the expense of removing hyperlinks from the bibliography) and try "\bibliographystyle{abbrv-doi-hyperref-narrow}" again after some more editing.

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.
- Merge multiple references into one; e.g., use [3, 5] (not [3] [5]). Within each set of multiple references, the references should be sorted in ascending order. This LATEX/bibTEX template takes care of both the merging and the sorting automatically.
- · Verify all data obtained from digital libraries, even ACM's DL and IEEE Xplore etc. are sometimes wrong or incomplete.
- Do not trust bibliographic data from other services such as Mendeley.com, Google Scholar, or similar; these are even more likely to be incorrect or incomplete.
- · Articles in journal—items to include:
 - author names
 - title
 - journal name
 - year
 - volume
 - number
 - 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 "Proc.\ name: e.g., 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"
- for all entries
 - DOI can be entered in the DOI field as plain DOI number or as DOI url; alternative: a url in the URL field
 - provide full page ranges AA--BB
- · when citing references, do not use the reference as a sentence object; e.g., wrong: "In [4] the authors describe ...", correct: "Lorensen and Cline [4] describe ..."

EXAMPLE SECTION

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam You can use nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam the erat, sed diam voluptua. At vero eos et accusam et justo duo dolores for comments et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est while editing Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et remove the dolore magna aliquyam erat, sed diam voluptua [3,5]. At vero eos et marginpar accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, comments for no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum submission. dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est.

5 EXPOSITION

Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi. Lorem ipsum dolor sit amet, consectetuer adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat [2].

$$\sum_{j=1}^{z} j = \frac{z(z+1)}{2} \tag{1}$$

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

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

	Vis/SciVis	conf				7 0	7.0	G&A	3&A
year	Vis/	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

5.1 Lorem ipsum

Lorem ipsum dolor sit amet (see Table 1), consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum.

5.2 Mezcal Head

Lorem ipsum dolor sit amet (see Fig. 2), consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet.

5.2.1 Duis Autem

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur

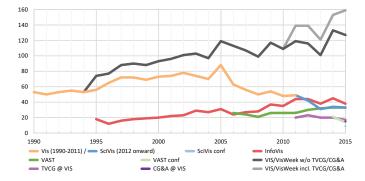


Fig. 2. A visualization of the 1990–2015 data from Table 1. The image is from [1] and is in the public domain.

sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est. Lorem ipsum dolor sit amet.

5.2.2 Ejector Seat Reservation

Duis autem [4]¹ vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat,² vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi. Lorem ipsum dolor sit amet, consectetuer adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat.

Confirmed Ejector Seat Reservation Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat [6]. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te feugait nulla facilisi.

Rejected Ejector Seat Reservation Ut wisi enim ad minim veniam, quis nostrud exerci tation ullamcorper suscipit lobortis nisl ut aliquip ex ea commodo consequat. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie

5.3 Vestibulum

Vestibulum ut est libero. Suspendisse non libero id massa congue egestas nec at ligula. Donec nibh lorem, ornare et odio eu, cursus accumsan felis. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec dapibus quam vel eros mattis, id ornare dolor convallis. Donec at nisl sapien. Integer fringilla laoreet tempor. Fusce accumsan ante vel augue euismod, sit amet maximus turpis mattis. Nam accumsan vestibulum rhoncus. Aenean quis pellentesque augue. Suspendisse sed augue et velit consequat bibendum id nec est. Quisque erat purus, ullamcorper ut ex vel, dapibus dignissim erat.

Quisque sit amet orci quam. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Aliquam pharetra, nunc non efficitur convallis, tellus purus iaculis lorem, nec ultricies dolor ligula in metus. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos. Aenean eu ex nulla. Morbi id ex interdum, scelerisque lorem nec, iaculis dui. Phasellus ultricies nunc vitae quam fringilla laoreet. Quisque sed dolor at sem vestibulum fringilla nec ac augue.

¹The algorithm behind Marching Cubes [4] had already been described by Wyvill et al. [7] a year earlier.

²Footnotes appear at the bottom of the column.

Ut consequat, velit ac mattis ornare, eros arcu pellentesque erat, non ultricies libero metus nec mi. Sed eget elit sed quam malesuada viverra. Quisque ullamcorper, felis ut convallis fermentum, purus ligula varius ligula, sit amet tempor neque dui non neque. Donec vulputate ultricies tortor in mollis.

Integer sit amet dolor sit amet turpis ullamcorper varius. Cras volutpat bibendum scelerisque. Maecenas mauris dolor, gravida eu elit et, sodales consequat tortor. Integer id commodo elit. Pellentesque sollicitudin ex non nulla molestie eleifend. Mauris sagittis metus nec turpis imperdiet, vel ullamcorper nibh tincidunt. Sed semper tempus ex, ut aliquet erat hendrerit id. Maecenas sit amet dolor sollicitudin, luctus nunc sit amet, malesuada justo.

Mauris ut sapien non ipsum imperdiet sodales sit amet ac diam. Nulla vel convallis est. Etiam dapibus augue urna. Aenean enim leo, fermentum quis pulvinar at, ultrices quis enim. Sed placerat porta libero et feugiat. Phasellus ullamcorper, felis id porta sollicitudin, dolor dui venenatis augue, vel fringilla risus massa non risus. Maecenas ut nulla vitae ligula pharetra feugiat non eu ante. Donec quis neque quis lorem cursus pretium ac vulputate quam. Cras viverra tellus vitae sapien pretium laoreet. Pellentesque fringilla odio venenatis ex viverra, quis eleifend tortor ornare. Ut ut enim nunc. Vivamus id ligula nec est dignissim eleifend.

Nunc ac velit tellus. Donec et venenatis mauris. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut vitae lectus vel ante mollis congue. Vestibulum at cursus velit. Curabitur in facilisis enim. Vestibulum eget dui aliquet risus laoreet laoreet. Phasellus et est id magna interdum venenatis. Donec luctus vehicula justo sed laoreet. Quisque tincidunt suscipit augue, in molestie sem accumsan sed.

6 Conclusion

Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum. Stet clita kasd gubergren, no sea takimata sanctus est Lorem ipsum dolor sit amet. Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor invidunt ut labore et dolore magna aliquyam erat, sed diam voluptua. At vero eos et accusam et justo duo dolores et ea rebum.

ACKNOWLEDGMENTS

The authors wish to thank A, B, and C. This work was supported in part by a grant from XYZ (# 12345-67890).

REFERENCES

- P. Isenberg, F. Heimerl, S. Koch, T. Isenberg, P. Xu, C. Stolper, M. Sedlmair, J. Chen, T. Möller, and J. Stasko. vispubdata.org: A Metadata Collection about IEEE Visualization (VIS) Publications. *IEEE Transactions on Visualization and Computer Graphics*, 23, 2017. To appear. doi: 10.1109/TVCG. 2016.2615308
- [2] G. Kindlmann. Semi-automatic generation of transfer functions for direct volume rendering. Master's thesis, Cornell University, USA, 1999.
- [3] Kitware, Inc. The Visualization Toolkit User's Guide, January 2003.
- [4] W. E. Lorensen and H. E. Cline. Marching cubes: A high resolution 3D surface construction algorithm. SIGGRAPH Computer Graphics, 21(4):163– 169, Aug. 1987. doi: 10.1145/37402.37422
- [5] N. Max. Optical models for direct volume rendering. *IEEE Transactions on Visualization and Computer Graphics*, 1(2):99–108, June 1995. doi: 10. 1109/2945.468400
- [6] G. M. Nielson and B. Hamann. The asymptotic decider: Removing the ambiguity in marching cubes. In *Proc. Visualization*, pp. 83–91. IEEE Computer Society, Los Alamitos, 1991. doi: 10.1109/VISUAL.1991.175782
- [7] G. Wyvill, C. McPheeters, and B. Wyvill. Data structure for soft objects. The Visual Computer, 2(4):227–234, Aug. 1986. doi: 10.1007/BF01900346