

# Outdoor Scene in Three.js using SPH, Crepuscular Rays, Firework Effects\*

Extended Abstract<sup>†</sup>

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## ABSTRACT

This paper provides insight into the creation of a multi-effect outdoor scene utilizing the javascript library, Three.js. The discussion will be centered around the implementation details using shader-based methods of smoothed particle hydrodynamics (SPH), crepuscular rays (God Rays), and a convincing firework effect.

## CCS CONCEPTS

• **Computing methodologies** → **Computer graphics; Physical simulation**; *Procedural animation; Rendering; Shape modeling*;

## KEYWORDS

CMPM 163, Game Graphics and Real Time Rendering, fireworks, smoothed particle hydrodynamics, god rays

### ACM Reference Format:

Brent Gingell, Eric Ventor, and Ivan Espiritu. 2018. Outdoor Scene in Three.js using SPH, Crepuscular Rays, Firework Effects: Extended Abstract. In *Proceedings of Game Graphics and Real Time Rendering (Final Project)*. ACM, New York, NY, USA, Article 4, 4 pages. [https://doi.org/10.475/123\\_4](https://doi.org/10.475/123_4)

## 1 INTRODUCTION

The following paper demonstrates a number of 3D graphics effects using shader-based rendering. The goal for the project was to create a scene utilizing complex effects that blend together to create a visually interesting whole. The work was done utilizing the WebGL and Javascript library Three.js with the goal of emphasizing a seamless blend of the interactions of the GPU and CPU to produce high quality effects in real time. Discussed in the following paper will be the implementation details for the effects. First will be a discussion on Smoothed Particle Hydrodynamics, a meshless technique for estimating the motion of complex fluid. Then the details for the implementation of Crepuscular or God Rays. Finally, the design for

a convincing firework effect. Also will be a discussion of integrating complex effect while maintaining a reasonable frame rate.

## 2 SMOOTHED PARTICLE HYDRODYNAMICS

Smoothed Particle Hydrodynamics is a Lagrangian approach to estimating the motion of fluids. The idea behind it is to discretize the fluid into a number of particles, then determine their physical properties by taking a weighted average over a set of local particles. It's because of this weighted average, in this project done with a cubic spline, for which the smoothed part of the name originates. SPH has advantaged compared to traditional fluid simulation approaches because it maintains the conservation of mass, momentum, and energy very naturally in its implementation.

### 2.1 Type Changes and *Special Characters*

We have already seen several typeface changes in this sample. You can indicate italicized words or phrases in your text with the command `\textit`; emboldening with the command `\textbf` and typewriter-style (for instance, for computer code) with `\texttt`. But remember, you do not have to indicate typestyle changes when such changes are part of the *structural* elements of your article; for instance, the heading of this subsection will be in a sans serif<sup>1</sup> typeface, but that is handled by the document class file. Take care with the use of<sup>2</sup> the curly braces in typeface changes; they mark the beginning and end of the text that is to be in the different typeface.

You can use whatever symbols, accented characters, or non-English characters you need anywhere in your document; you can find a complete list of what is available in the *L<sup>A</sup>T<sub>E</sub>X User's Guide* [?].

### 2.2 Math Equations

You may want to display math equations in three distinct styles: inline, numbered or non-numbered display. Each of the three are discussed in the next sections.

**2.2.1 Inline (In-text) Equations.** A formula that appears in the running text is called an inline or in-text formula. It is produced by the **math** environment, which can be invoked with the usual `\begin . . . \end` construction or with the short form `$ . . . $`. You can use any of the symbols and structures, from  $\alpha$  to  $\omega$ , available in L<sup>A</sup>T<sub>E</sub>X [?]; this section will simply show a few examples of in-text equations in context. Notice how this equation:  $\lim_{n \rightarrow \infty} x = 0$ ,

\*Produces the permission block, and copyright information

<sup>†</sup>The full version of the author's guide is available as `acmart.pdf` document

<sup>‡</sup>insisted his name be first.

<sup>§</sup>the river bell tolls at noon

<sup>¶</sup>too dumb to come up with an author note

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Final Project, March 2018, Santa Cruz, California USA

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ACM ISBN 123-4567-24-567/08/06...\$15.00

[https://doi.org/10.475/123\\_4](https://doi.org/10.475/123_4)

<sup>1</sup>Another footnote here. Let's make this a rather long one to see how it looks.

<sup>2</sup>Another footnote.

set here in in-line math style, looks slightly different when set in display style. (See next section).

2.2.2 *Display Equations.* A numbered display equation—one set off by vertical space from the text and centered horizontally—is produced by the `equation` environment. An unnumbered display equation is produced by the `displaymath` environment.

Again, in either environment, you can use any of the symbols and structures available in  $\LaTeX$ ; this section will just give a couple of examples of display equations in context. First, consider the equation, shown as an inline equation above:

$$\lim_{n \rightarrow \infty} x = 0$$

(1)

Notice how it is formatted somewhat differently in the `displaymath` environment. Now, we'll enter an unnumbered equation:

$$\sum_{i=0}^{\infty} x + 1$$

and follow it with another numbered equation:

$$\sum_{i=0}^{\infty} x_i = \int_0^{\pi+2} f$$

(2)

just to demonstrate  $\LaTeX$ 's able handling of numbering.

2.3 Citations

Citations to articles [? ? ? ?], conference proceedings [?] or maybe books [?] listed in the Bibliography section of your article will occur throughout the text of your article. You should use BibTeX to automatically produce this bibliography; you simply need to insert one of several citation commands with a key of the item cited in the proper location in the .tex file [?]. The key is a short reference you invent to uniquely identify each work; in this sample document, the key is the first author's surname and a word from the title. This identifying key is included with each item in the .bib file for your article.

The details of the construction of the .bib file are beyond the scope of this sample document, but more information can be found in the *Author's Guide*, and exhaustive details in the *LaTeX User's Guide* by L<sup>a</sup>mpo<sup>r</sup>t [?].

This article shows only the plainest form of the citation command, using \cite.

Some examples. A paginated journal article [?], an enumerated journal article [?], a reference to an entire issue [?], a monograph (whole book) [?], a monograph/whole book in a series (see 2a in spec. document) [?], a divisible-book such as an anthology or compilation [?] followed by the same example, however we only output the series if the volume number is given [?] (so Editor00a's series should NOT be present since it has no vol. no.), a chapter in a divisible book [?], a chapter in a divisible book in a series [?], a multi-volume work as book [?], an article in a proceedings (of a conference, symposium, workshop for example) (paginated proceedings article) [?], a proceedings article with all possible elements [?], an example of an enumerated proceedings article [?], an informally published work [?], a doctoral dissertation [?], a master's thesis: [?], an online document / world wide web resource [? ? ?], a video game (Case 1) [?] and (Case 2) [?] and [?] and (Case 3) a patent [?], work accepted for publication [?], 'YYYYb'-test for

Table 1: Frequency of Special Characters

Non-English or Math	Frequency	Comments
∅	1 in 1,000	For Swedish names
π	1 in 5	Common in math
\$	4 in 5	Used in business
Ψ <sub>1</sub> <sup>2</sup>	1 in 40,000	Unexplained usage

prolific author [?] and [?]. Other cites might contain 'duplicate' DOI and URLs (some SIAM articles) [?]. Boris / Barbara Beeton: multi-volume works as books [?] and [?].

A couple of citations with DOIs: [? ?].

Online citations: [? ? ?].

2.4 Tables

Because tables cannot be split across pages, the best placement for them is typically the top of the page nearest their initial cite. To ensure this proper "floating" placement of tables, use the environment `table` to enclose the table's contents and the table caption. The contents of the table itself must go in the `tabular` environment, to be aligned properly in rows and columns, with the desired horizontal and vertical rules. Again, detailed instructions on `tabular` material are found in the *LaTeX User's Guide*.

Immediately following this sentence is the point at which Table 1 is included in the input file; compare the placement of the table here with the table in the printed output of this document.

To set a wider table, which takes up the whole width of the page's live area, use the environment `table*` to enclose the table's contents and the table caption. As with a single-column table, this wide table will "float" to a location deemed more desirable. Immediately following this sentence is the point at which Table 2 is included in the input file; again, it is instructive to compare the placement of the table here with the table in the printed output of this document.

It is strongly recommended to use the package booktabs [?] and follow its main principles of typography with respect to tables:

- (1) Never, ever use vertical rules.
- (2) Never use double rules.

It is also a good idea not to overuse horizontal rules.

2.5 Figures

Like tables, figures cannot be split across pages; the best placement for them is typically the top or the bottom of the page nearest their initial cite. To ensure this proper "floating" placement of figures, use the environment `figure` to enclose the figure and its caption.

This sample document contains examples of .eps files to be displayable with  $\LaTeX$ . If you work with pdf $\LaTeX$ , use files in the .pdf format. Note that most modern  $\TeX$  systems will convert .eps to .pdf for you on the fly. More details on each of these are found in the *Author's Guide*.

As was the case with tables, you may want a figure that spans two columns. To do this, and still to ensure proper "floating" placement of tables, use the environment `figure*` to enclose the figure and its caption. And don't forget to end the environment with `figure*`, not `figure`!

Table 2: Some Typical Commands

Command	A Number	Comments
<code>\author</code>	100	Author
<code>\table</code>	300	For tables
<code>\table*</code>	400	For wider tables



Figure 1: A sample black and white graphic.

Figure 2: A sample black and white graphic that has been resized with the `includegraphics` command.

## 2.6 Theorem-like Constructs

Other common constructs that may occur in your article are the forms for logical constructs like theorems, axioms, corollaries and proofs. ACM uses two types of these constructs: theorem-like and definition-like.

Here is a theorem:

**THEOREM 2.1.** *Let  $f$  be continuous on  $[a, b]$ . If  $G$  is an antiderivative for  $f$  on  $[a, b]$ , then*

$$\int_a^b f(t) dt = G(b) - G(a).$$

Here is a definition:

**Definition 2.2.** If  $z$  is irrational, then by  $e^z$  we mean the unique number that has logarithm  $z$ :

$$\log e^z = z.$$

The pre-defined theorem-like constructs are **theorem**, **conjecture**, **proposition**, **lemma** and **corollary**. The pre-defined definition-like constructs are **example** and **definition**. You can add your own constructs using the `amsthm` interface [?]. The styles used in the `\theoremstyle` command are **acmplain** and **acmdefinition**.

Another construct is **proof**, for example,

**PROOF.** Suppose on the contrary there exists a real number  $L$  such that

$$\lim_{x \rightarrow \infty} \frac{f(x)}{g(x)} = L.$$

Then

$$l = \lim_{x \rightarrow c} f(x) = \lim_{x \rightarrow c} \left[ g(x) \cdot \frac{f(x)}{g(x)} \right] = \lim_{x \rightarrow c} g(x) \cdot \lim_{x \rightarrow c} \frac{f(x)}{g(x)} = 0 \cdot L = 0,$$

which contradicts our assumption that  $l \neq 0$ .  $\square$

## 3 CONCLUSIONS

This paragraph will end the body of this sample document. Remember that you might still have Acknowledgments or Appendices; brief samples of these follow. There is still the Bibliography to deal with; and we will make a disclaimer about that here: with the exception of the reference to the  $\text{\LaTeX}$  book, the citations in this paper are to articles which have nothing to do with the present subject and are used as examples only.

## A HEADINGS IN APPENDICES

The rules about hierarchical headings discussed above for the body of the article are different in the appendices. In the **appendix** environment, the command **section** is used to indicate the start of each Appendix, with alphabetic order designation (i.e., the first is A, the second B, etc.) and a title (if you include one). So, if you need hierarchical structure *within* an Appendix, start with **subsection** as the highest level. Here is an outline of the body of this document in Appendix-appropriate form:

### A.1 Introduction

### A.2 The Body of the Paper

#### A.2.1 Type Changes and Special Characters.

#### A.2.2 Math Equations.

#### Inline (In-text) Equations.

#### Display Equations.

#### A.2.3 Citations.

#### A.2.4 Tables.

#### A.2.5 Figures.

#### A.2.6 Theorem-like Constructs.

#### A Caveat for the $\text{\TeX}$ Expert.

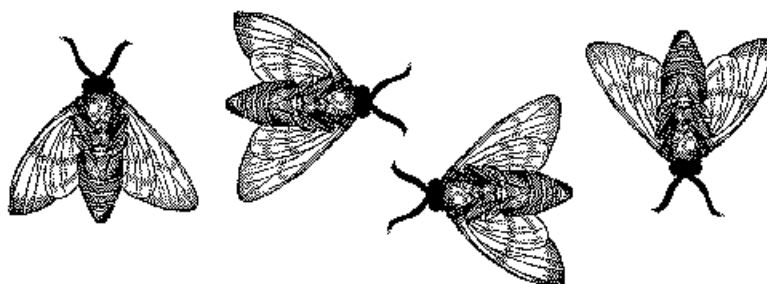
### A.3 Conclusions

### A.4 References

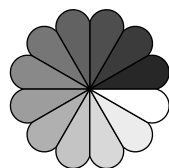
Generated by bibtex from your `.bib` file. Run latex, then bibtex, then latex twice (to resolve references) to create the `.bbl` file. Insert that `.bbl` file into the `.tex` source file and comment out the command `\thebibliography`.

## B MORE HELP FOR THE HARDY

Of course, reading the source code is always useful. The file `acmart.pdf` contains both the user guide and the commented code.



**Figure 3: A sample black and white graphic that needs to span two columns of text.**



**Figure 4: A sample black and white graphic that has been resized with the `includegraphics` command.**

## **ACKNOWLEDGMENTS**

The authors would like to thank Dr. Yuhua Li for providing the MATLAB code of the *BEPS* method.

The authors would also like to thank the anonymous referees for their valuable comments and helpful suggestions. The work is supported by the National Natural Science Foundation of China under Grant No.: 61273304 and Young Scientists' Support Program (<http://www.nnsf.cn/youngscientists>).