

# Context-Aware and Physics-Align LLM-Social Force Model (CAPL-SFM) Crowd Simulator

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## Abstract

We present LLM-SFM Translator, a context-aware and physics-aligned framework for trajectory generation and crowd simulation in unseen scenarios. Given scene images and natural-language prompts, the proposed method translates high-level contextual descriptions into physically grounded Social Force Model parameters and agent trajectories. To improve behavioral fidelity and physical consistency, we incorporate reinforcement learning from AI feedback (RL-AIF) to distill reasoning and decision patterns from large language models into a stable translator. We further introduce a novel evaluation framework with a benchmark dataset that combines statistical metrics, agent-level behavioral consistency, LLM-based judgment, and human evaluation. Experiments on standard and unseen environments demonstrate improved generalization, interpretability, and physical plausibility over existing learning-based and controllable simulation baselines.

## 1 Introduction

The *IJCAI-ECAI 26 Proceedings* will be printed from electronic manuscripts submitted by the authors. These must be PDF (*Portable Document Format*) files formatted for 8-1/2" × 11" paper.

### 1.1 Length of Papers

All paper *submissions* to the main track must have a maximum of seven pages, plus at most two for references / acknowledgements / contribution statement / ethics statement.

The length rules may change for final camera-ready versions of accepted papers and differ between tracks. Some tracks may disallow any contents other than the references in the last two pages, whereas others allow for any content in all pages. Similarly, some tracks allow you to buy a few extra pages should you want to, whereas others don't.

If your paper is accepted, please carefully read the notifications you receive, and check the proceedings submission information website<sup>1</sup> to know how many pages you can use

for your final version. That website holds the most up-to-date information regarding paper length limits at all times.

## 1.2 Word Processing Software

As detailed below, IJCAI has prepared and made available a set of L<sup>A</sup>T<sub>E</sub>X macros and a Microsoft Word template for use in formatting your paper. If you are using some other word processing software, please follow the format instructions given below and ensure that your final paper looks as much like this sample as possible.

## 2 Related Work

L<sup>A</sup>T<sub>E</sub>X and Word style files that implement these instructions can be retrieved electronically. (See Section 9 for instructions on how to obtain these files.)

### 2.1 Crowd Simulation

Print manuscripts two columns to a page, in the manner in which these instructions are printed. The exact dimensions for pages are:

- left and right margins: .75"
- column width: 3.375"
- gap between columns: .25"
- top margin—first page: 1.375"
- top margin—other pages: .75"
- bottom margin: 1.25"
- column height—first page: 6.625"
- column height—other pages: 9"

All measurements assume an 8-1/2" × 11" page size. For A4-size paper, use the given top and left margins, column width, height, and gap, and modify the bottom and right margins as necessary.

### 2.2 Trajectory Generation

For the production of the electronic manuscript, you must use Adobe's *Portable Document Format* (PDF). A PDF file can be generated, for instance, on Unix systems using `ps2pdf` or on Windows systems using Adobe's Distiller. There is also a website with free software and conversion services: <http://www.ps2pdf.com>. For reasons of uniformity, use of Adobe's

<sup>1</sup><https://proceedings.ijcai.org/info>

75 *Times Roman* font is strongly suggested. In L<sup>A</sup>T<sub>E</sub>X2e this is  
76 accomplished by writing

77 `\usepackage{times}`

78 in the preamble.<sup>2</sup>

79 Additionally, it is of utmost importance to specify the **let-**  
80 **ter** format (corresponding to 8-1/2" × 11") when formatting  
81 the paper. When working with dvips, for instance, one  
82 should specify `-t letter`.

## 83 2.3 LLM Physics Parameters Translator

84 In this document, we distinguish between papers submitted  
85 for review (henceforth, submissions) and camera-ready ver-  
86 sions, i.e., accepted papers that will be included in the con-  
87 ference proceedings. The present document provides infor-  
88 mation to be used by both types of papers (submissions /  
89 camera-ready). There are relevant differences between the  
90 two versions. Find them next.

### 91 Anonymity

92 For the main track and some of the special tracks, sub-  
93 missions must be anonymous; for other special tracks they  
94 must be non-anonymous. The camera-ready versions for all  
95 tracks are non-anonymous. When preparing your submis-  
96 sion, please check the track-specific instructions regarding  
97 anonymity.

### 98 Submissions

99 The following instructions apply to submissions:

- 100 • If your track requires submissions to be anonymous,  
101 they must be fully anonymized as discussed in the Mod-  
102 ifications for Blind Review subsection below; in this  
103 case, Acknowledgements and Contribution Statement  
104 sections are not allowed.
- 105 • If your track requires non-anonymous submissions, you  
106 should provide all author information at the time of  
107 submission, just as for camera-ready papers (see be-  
108 low); Acknowledgements and Contribution Statement  
109 sections are allowed, but optional.
- 110 • Submissions must include line numbers to facilitate  
111 feedback in the review process. Enable line numbers by  
112 uncommenting the command `\linenumbers` in the  
113 preamble.
- 114 • The limit on the number of content pages is *strict*. All  
115 papers exceeding the limits will be desk rejected.

### 116 Camera-Ready Papers

117 The following instructions apply to camera-ready papers:

- 118 • Authors and affiliations are mandatory. Explicit self-  
119 references are allowed. It is strictly forbidden to add  
120 authors not declared at submission time.
- 121 • Acknowledgements and Contribution Statement sec-  
122 tions are allowed, but optional.
- 123 • Line numbering must be disabled. To achieve this, com-  
124 ment or disable `\linenumbers` in the preamble.
- 125 • For some of the tracks, you can exceed the page limit by  
126 purchasing extra pages.

<sup>2</sup>You may want to also use the package `latexsym`, which de-  
fines all symbols known from the old L<sup>A</sup>T<sub>E</sub>X version.

## 2.4 Title and Author Information 127

Center the title on the entire width of the page in a 14-point  
bold font. The title must be capitalized using Title Case. For  
non-anonymous papers, author names and affiliations should  
appear below the title. Center author name(s) in 12-point bold  
font. On the following line(s) place the affiliations. 128  
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### Author Names 133

Each author name must be followed by: 134

- A newline `\\` command for the last author. 135
- An `\And` command for the second to last author. 136
- An `\and` command for the other authors. 137

### Affiliations 138

After all authors, start the affiliations section by using the  
`\affiliations` command. Each affiliation must be termi-  
nated by a newline `\\` command. Make sure that you include  
the newline after the last affiliation, too. 139  
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### Mapping Authors to Affiliations 143

If some scenarios, the affiliation of each author is clear with-  
out any further indication (e.g., all authors share the same  
affiliation, all authors have a single and different affiliation).  
In these situations you don't need to do anything special. 144  
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In more complex scenarios you will have to clearly indi-  
cate the affiliation(s) for each author. This is done by using  
numeric math superscripts  $\{^i, ^j, \dots\}$ . You must use num-  
bers, not symbols, because those are reserved for footnotes in  
this section (should you need them). Check the authors defi-  
nition in this example for reference. 148  
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### Emails 154

This section is optional, and can be omitted entirely if you  
prefer. If you want to include e-mails, you should either in-  
clude all authors' e-mails or just the contact author(s)' ones. 155  
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Start the e-mails section with the `\emails` command. Af-  
ter that, write all emails you want to include separated by a  
comma and a space, following the order used for the authors  
(i.e., the first e-mail should correspond to the first author, the  
second e-mail to the second author and so on). 158  
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You may "contract" consecutive e-mails on the same do-  
main as shown in this example (write the users' part within  
curly brackets, followed by the domain name). Only e-  
mails of the exact same domain may be contracted. For  
instance, you cannot contract "person@example.com" and  
"other@test.example.com" because the domains are differ-  
ent. 163  
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### Modifications for Blind Review 170

When submitting to a track that requires anonymous submis-  
sions, in order to make blind reviewing possible, authors must  
omit their names, affiliations and e-mails. In place of names,  
affiliations and e-mails, you can optionally provide the sub-  
mission number and/or a list of content areas. When referring  
to one's own work, use the third person rather than the first  
person. For example, say, "Previously, Gottlob [1992] has  
shown that...", rather than, "In our previous work [Gottlob,  
1992], we have shown that..." Try to avoid including any  
information in the body of the paper or references that would  
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181 identify the authors or their institutions, such as acknowl-  
182 edgements. Such information can be added post-acceptance  
183 to be included in the camera-ready version. Please also make  
184 sure that your paper metadata does not reveal the authors’  
185 identities.

## 186 2.5 Social Force Model

187 Place the abstract at the beginning of the first column 3'' from  
188 the top of the page, unless that does not leave enough room  
189 for the title and author information. Use a slightly smaller  
190 width than in the body of the paper. Head the abstract with  
191 “Abstract” centered above the body of the abstract in a 12-  
192 point bold font. The body of the abstract should be in the  
193 same font as the body of the paper.

194 The abstract should be a concise, one-paragraph summary  
195 describing the general thesis and conclusion of your paper. A  
196 reader should be able to learn the purpose of the paper and  
197 the reason for its importance from the abstract. The abstract  
198 should be no more than 200 words long.

## 199 2.6 Text

200 The main body of the text immediately follows the abstract.  
201 Use 10-point type in a clear, readable font with 1-point lead-  
202 ing (10 on 11).

203 Indent when starting a new paragraph, except after major  
204 headings.

## 205 2.7 Headings and Sections

206 When necessary, headings should be used to separate major  
207 sections of your paper. (These instructions use many head-  
208 ings to demonstrate their appearance; your paper should have  
209 fewer headings.). All headings should be capitalized using  
210 Title Case.

### 211 Section Headings

212 Print section headings in 12-point bold type in the style shown  
213 in these instructions. Leave a blank space of approximately  
214 10 points above and 4 points below section headings. Number  
215 sections with Arabic numerals.

### 216 Subsection Headings

217 Print subsection headings in 11-point bold type. Leave a  
218 blank space of approximately 8 points above and 3 points be-  
219 low subsection headings. Number subsections with the sec-  
220 tion number and the subsection number (in Arabic numerals)  
221 separated by a period.

### 222 Subsubsection Headings

223 Print subsubsection headings in 10-point bold type. Leave a  
224 blank space of approximately 6 points above subsubsection  
225 headings. Do not number subsubsections.

226 **Titled paragraphs.** You should use titled paragraphs if and  
227 only if the title covers exactly one paragraph. Such para-  
228 graphs should be separated from the preceding content by at  
229 least 3pt, and no more than 6pt. The title should be in 10pt  
230 bold font and to end with a period. After that, a 1em horizon-  
231 tal space should follow the title before the paragraph’s text.

232 In L<sup>A</sup>T<sub>E</sub>X titled paragraphs should be typeset using

233 `\paragraph{Title.} text.`

## 234 2.8 Special Sections

### 235 Appendices

236 You may move some of the contents of the paper into one  
237 or more appendices that appear after the main content, but  
238 before references. These appendices count towards the page  
239 limit and are distinct from the supplementary material that  
240 can be submitted separately through CMT. Such appendices  
241 are useful if you would like to include highly technical mate-  
242 rial (such as a lengthy calculation) that will disrupt the flow of  
243 the paper. They can be included both in papers submitted for  
244 review and in camera-ready versions; in the latter case, they  
245 will be included in the proceedings (whereas the supplement-  
246 ary materials will not be included in the proceedings). Ap-  
247 pendices are optional. Appendices must appear after the main  
248 content. Appendix sections must use letters instead of Ara-  
249 bic numerals. In L<sup>A</sup>T<sub>E</sub>X, you can use the `\appendix` com-  
250 mand to achieve this followed by `\section{Appendix}`  
251 for your appendix sections.

### 252 Ethical Statement

253 Ethical Statement is optional. You may include an Ethical  
254 Statement to discuss the ethical aspects and implications of  
255 your research. The section should be titled *Ethical Statement*  
256 and be typeset like any regular section but without being num-  
257 bered. This section may be placed on the References pages.

258 Use

259 `\section*{Ethical Statement}`

### 260 Acknowledgements

261 Acknowledgements are optional. In the camera-ready version  
262 you may include an unnumbered acknowledgments section,  
263 including acknowledgments of help from colleagues, finan-  
264 cial support, and permission to publish. This is not allowed  
265 in the anonymous submission. If present, acknowledgements  
266 must be in a dedicated, unnumbered section appearing after  
267 all regular sections but before references. This section may  
268 be placed on the References pages.

269 Use

270 `\section*{Acknowledgements}`

271 to typeset the acknowledgements section in L<sup>A</sup>T<sub>E</sub>X.

### 272 Contribution Statement

273 Contribution Statement is optional. In the camera-ready ver-  
274 sion you may include an unnumbered Contribution Statement  
275 section, explicitly describing the contribution of each of the  
276 co-authors to the paper. This is not allowed in the anonymous  
277 submission. If present, Contribution Statement must be in  
278 a dedicated, unnumbered section appearing after all regular  
279 sections but before references. This section may be placed on  
280 the References pages.

281 Use

282 `\section*{Contribution Statement}`

283 to typeset the Contribution Statement section in L<sup>A</sup>T<sub>E</sub>X.

### 284 References

285 The references section is headed “References”, printed in the  
286 same style as a section heading but without a number. A  
287 sample list of references is given at the end of these instruc-  
288 tions. Use a consistent format for references. The reference  
289 list should not include publicly unavailable work.



Figure 1: Real world map to obstacle map.

## Order of Sections

Sections should be arranged in the following order:

1. Main content sections (numbered)
2. Appendices (optional, numbered using capital letters)
3. Ethical statement (optional, unnumbered)
4. Acknowledgements (optional, unnumbered)
5. Contribution statement (optional, unnumbered)
6. References (required, unnumbered)

## 2.9 Citations

Citations within the text should include the author’s last name and the year of publication, for example [Gottlob, 1992]. Append lowercase letters to the year in cases of ambiguity. Treat multiple authors as in the following examples: [Abelson *et al.*, 1985] or [Baumgartner *et al.*, 2001] (for more than two authors) and [Brachman and Schmolze, 1985] (for two authors). If the author portion of a citation is obvious, omit it, e.g., Nebel [2000]. Collapse multiple citations as follows: [Gottlob *et al.*, 2002; Levesque, 1984a].

## 2.10 Footnotes

Place footnotes at the bottom of the page in a 9-point font. Refer to them with superscript numbers.<sup>3</sup> Separate them from the text by a short line.<sup>4</sup> Avoid footnotes as much as possible; they interrupt the flow of the text.

## 3 Methodology

### 3.1 Dataset Creation

To get a dataset that could demonstrate crowd in public area, we scripted around 100 world famous public places maps including tourists-heavy area, stadiums, university campus and public transportation hub. We then implemented an image to obstacle data processing pipeline using the colormap provided by Google Map official API as well as segmentation model and Polygon proximity algorithm. The script real world map size is fixed with a width around 301.7 m, height around 282.8 m.

To generate the contextual description of crowd scenarios, we categorize the crowd into different types based on Berlonghi (TODO)’s crowd psychological theory, including casual gathering, spectator crowd, expressive crowd, and aggressive crowd. In total we have 11 categories of different

<sup>3</sup>This is how your footnotes should appear.

<sup>4</sup>Note the line separating these footnotes from the text.

Attribute	Meaning
scenario	Contextual descriptions generated by GPT-5.1
category	The crowd category that this scenario belongs to
crowd_size	Agents numbers inside this map
event_center	Pixel coordinates of the synthetic event center of the
goal_location	Pixel coordinates of the synthetic goal locations based on

Table 1: Attributes inside the synthetic dataset.

Scenario	$\delta$ (s)	Runtime (ms)
Paris	0.1	13.65
	0.2	0.01
New York	0.1	92.50
Singapore	0.1	33.33
	0.2	23.01

Table 2: Booktabs table

crowd. We then designed a prompt template to let GPT-5.1 to generate high level and diverse natural language descriptions for each type of crowd scenario. In total we gathered around 50k context descriptions.

To further quantify the results of the crowd simulation, we also let GPT-5.1 to generate possible exits and event center, together with their pixel coordinates in the map. Table 1 shows all the information we designed to let gpt-5.1 generate.

## 4 Evaluation

Tables are treated as illustrations containing data. Therefore, they should also appear floated to the top (preferably) or bottom of the page, and with the captions below them.

If you are using  $\LaTeX$ , you should use the `booktabs` package, because it produces tables that are better than the standard ones. Compare Tables 1 and 2. The latter is clearly more readable for three reasons:

1. The styling is better thanks to using the `booktabs` rulers instead of the default ones.
2. Numeric columns are right-aligned, making it easier to compare the numbers. Make sure to also right-align the corresponding headers, and to use the same precision for all numbers.
3. We avoid unnecessary repetition, both between lines (no need to repeat the scenario name in this case) as well as in the content (units can be shown in the column header).

## 5 Results

IJCAI’s two-column format makes it difficult to typeset long formulas. A usual temptation is to reduce the size of the formula by using the `small` or `tiny` sizes. This doesn’t work correctly with the current  $\LaTeX$  versions, breaking the line spacing of the preceding paragraphs and title, as well as the equation number sizes. The following equation demonstrates the effects (notice that this entire paragraph looks badly formatted, and the line numbers no longer match the text):

$$x = \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i \quad (1)$$

Reducing formula sizes this way is strictly forbidden. We **strongly** recommend authors to split formulas in multiple lines when they don't fit in a single line. This is the easiest approach to typeset those formulas and provides the most readable output

$$x = \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i. \quad (2)$$

If a line is just slightly longer than the column width, you may use the `resizebox` environment on that equation. The result looks better and doesn't interfere with the paragraph's line spacing:

$$x = \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i. \quad (3)$$

This last solution may have to be adapted if you use different equation environments, but it can generally be made to work. Please notice that in any case:

- Equation numbers must be in the same font and size as the main text (10pt).
- Your formula's main symbols should not be smaller than small text (9pt).

For instance, the formula

$$x = \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j + \prod_{i=1}^n \sum_{j=1}^n j_i + \prod_{i=1}^n \sum_{j=1}^n i_j \quad (4)$$

would not be acceptable because the text is too small.

## 6 Ablation Study

Examples, definitions, theorems, corollaries and similar must be written in their own paragraph. The paragraph must be separated by at least 2pt and no more than 5pt from the preceding and succeeding paragraphs. They must begin with the kind of item written in 10pt bold font followed by their number (e.g.: **Theorem 1**), optionally followed by a title/summary between parentheses in non-bold font and ended with a period (in bold). After that the main body of the item follows, written in 10 pt italics font (see below for examples).

In  $\LaTeX$  we strongly recommend that you define environments for your examples, definitions, propositions, lemmas, corollaries and similar. This can be done in your  $\LaTeX$  preamble using `\newtheorem` – see the source of this document for examples. Numbering for these items must be global, not per-section (e.g.: Theorem 1 instead of Theorem 6.1).

**Example 1** (How to write an example). *Examples should be written using the example environment defined in this template.*

**Theorem 1.** *This is an example of an untitled theorem.*

You may also include a title or description using these environments as shown in the following theorem.

**Theorem 2** (A titled theorem). *This is an example of a titled theorem.*

## Algorithm 1 Example algorithm

**Input:** Your algorithm's input

**Parameter:** Optional list of parameters

**Output:** Your algorithm's output

```
1: Let  $t = 0$ .
2: while condition do
3:   Do some action.
4:   if conditional then
5:     Perform task A.
6:   else
7:     Perform task B.
8:   end if
9: end while
10: return solution
```

## 7 Discussion

Proofs must be written in their own paragraph(s) separated by at least 2pt and no more than 5pt from the preceding and succeeding paragraphs. Proof paragraphs should start with the keyword "Proof." in 10pt italics font. After that the proof follows in regular 10pt font. At the end of the proof, an unfilled square symbol (qed) marks the end of the proof.

In  $\LaTeX$  proofs should be typeset using the `\proof` environment.

*Proof.* This paragraph is an example of how a proof looks like using the `\proof` environment.  $\square$

## 8 Conclusion

Algorithms and listings are a special kind of figures. Like all illustrations, they should appear floated to the top (preferably) or bottom of the page. However, their caption should appear in the header, left-justified and enclosed between horizontal lines, as shown in Algorithm 1. The algorithm body should be terminated with another horizontal line. It is up to the authors to decide whether to show line numbers or not, how to format comments, etc.

In  $\LaTeX$  algorithms may be typeset using the `algorithm` and `algorithmic` packages, but you can also use one of the many other packages for the task.

## 9 $\LaTeX$ and Word Style Files

The  $\LaTeX$  and Word style files are available on the IJCAI-ECAI 26 website, <https://2026.ijcai.org/>. These style files implement the formatting instructions in this document.

The  $\LaTeX$  files are `ijcai26.sty` and `ijcai26.tex`, and the Bib $\TeX$  files are named `.bst` and `ijcai26.bib`. The  $\LaTeX$  style file is for version 2e of  $\LaTeX$ , and the Bib $\TeX$  style file is for version 0.99c of Bib $\TeX$  (not version 0.98i).

The Microsoft Word style file consists of a single file, `ijcai26.docx`.

These Microsoft Word and  $\LaTeX$  files contain the source of the present document and may serve as a formatting sample.

Further information on using these styles for the preparation of papers for IJCAI-ECAI 26 can be obtained by contacting [proceedings@ijcai.org](mailto:proceedings@ijcai.org).

## Ethical Statement

There are no ethical issues.

## Acknowledgments

The preparation of these instructions and the  $\text{\LaTeX}$  and  $\text{\BibTeX}$  files that implement them was supported by Schlumberger Palo Alto Research, AT&T Bell Laboratories, and Morgan Kaufmann Publishers. Preparation of the Microsoft Word file was supported by IJCAI. An early version of this document was created by Shirley Jowell and Peter F. Patel-Schneider. It was subsequently modified by Jennifer Ballentine, Thomas Dean, Bernhard Nebel, Daniel Pagenstecher, Kurt Steinkraus, Toby Walsh, Carles Sierra, Marc Pujol-Gonzalez, Francisco Cruz-Mencia and Edith Elkind.

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