Unsupervised learning for joint depth and normal estimation

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Abstract

We propose an unsupervised learning framework for joint estimation of scene depth and normal in single images. Similar to recent work [1,2,3], we implement an end-to-end network that leverages the view synthesis and geometry consistency in videos as the supervision. Our method takes monocular videos as input and outputs camera motion, depth and surface normal. Evaluation of depth and normal on KITTI 2015 dataset demonstrates the effectiveness of our approach: our method has outperforms current state-of-the-art performance in terms of depth and normal evaluation metrics.

1 Introduction

Depth and normal estimation has been explored in multiple

2 Related Work

2.1 Supervised depth and normal estimation

2.2 Unsupervised learning for low-level vision

2.3 Spatial transformer network

3 Method

In this section, we describe the framework architecture and training procedure in detail. Our intuition is to train a CNN that is capable of modeling the geometry consistency of a mostly rigid scene. To facilitate the learning of the network, we explicitly propose to model the constraint between depth and normal. The training samples of the framework consist of frame sequences captured by a monocular moving camera.

3.1 Objective function

To model a reasonable geometrical consistency, we propose the overall objective function as in Equation **??**.

$$L(D, I, Rt, \lambda) = L_{warp}(D, I, Rt) + L_{smooth}(D, N, I)$$
$$+L_{grad}(D, I, Rt) + \lambda(L_{dn}(D, N)) \quad (1)$$

This objective function is a Lagrange fuction aiming to minimize the loss term $L_{warp}(D, I, Rt) + L_{smooth}(D, N, I)$
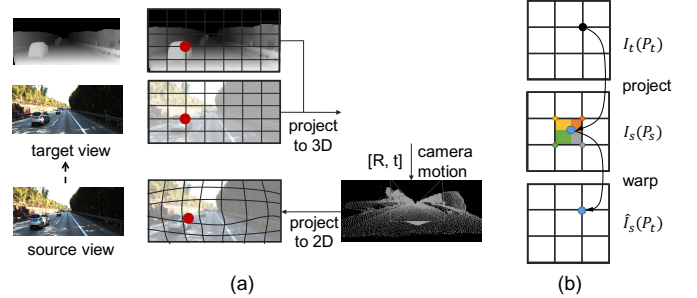
Figure 1: Illustraion of (a) 3D inverse warping and (b) bilinear interpolation.

$+ L_{grad}(D, I, Rt)$ subject to the constraint of geometrical constraint between depth map and normal map $L_{d}n(D, N) = 0$. The loss term consists of three components: photometric warping loss $L_{warp}(D, I, Rt)$, smoothness loss $L_{smooth}(D, N, I)$, image gradient matching loss $L_{grad}(D, I, Rt)$.

Photometric warping loss. One main supervision of our framework comes from novel view synthesis: given an input view of a scene and camera motion, synthesize an image of the scene seen from a different view. We can synthesize an image of the target view given the image of source view, camera motion from target view to source view and depth map of target view, using 3D inverse warping. The process of warping is shown in Figure **??**. Each pixel (point on the grid) of depth map is first mapped onto 3D space. The 3D point cloud is transformed based on camera motion and then mapped back to 2D plane. Each grid point in target view corresponds to one point in source view. Similar to (**?**), the bilinear interpolation is implemented to calculate each pixel value of warped image as a weighted sum of four nearest neighboring pixels in source image, weighted by the square area between the projected point and neighboring point, as shown in Figure **??** (b).

The warping loss is a photometric difference between the target image and warped image.

$$L_{warp}(D, I, Rt) = \sum_s \sum_p |I_t - \hat{I}_s|$$

In which, s iterates the number of source image, p iterates

each pixel in the image, I_t is the target image, I_s is the source image, $\hat{I}_s = \tau(I_s, D_t, Rt)$ is the warped image, τ is the warping function as introduced above.

Edge-aware smoothness loss. One issue with using only view synthesis as supervision is that the back-propagation gradients are solely derived from the pixel value difference between one point in target image and weighted sum of its four neighboring points in source image. The warping loss will not be useful for learning where the point falls on low-texture regions. The predicted depth on these regions can be of any value as long as the warped region has the similar pixel value. To overcome this issue, a prior knowledge of the scene geometry is incorporated for a smoothness loss:

$$L_{smooth}(D) = \frac{1}{p}\sum_{p}(|\partial_x^2 X_p|e^{(-\alpha||\partial_x I_p||)} + |\partial_y^2 D_p|e^{(-\alpha||\partial_y I_p||)})$$

This smoothness term penalizes the norm of second-order gradients of depth in order to encourage smoothly changing depth values. As depth discontinuity often happens at image gradients, the smoothness loss is weighted by the a function of image gradients to prevent smoothed depth at image gradients.

Image gradient matching loss.

To further facilitate the macthing of target image and warped image, and to encourage the depth map to be sharp, the photometric difference of gradient maps of target image and warped image is cacluated as gradient matching loss.

$$L_{grad}(D, I, Rt) = \sum_{s}(|\partial_x I_t - \partial_x \hat{I}_s| + |\partial_y I_t - \partial_y \hat{I}_s|)$$

3.2 Geometry consistency

As depth and surface normal are not independent under the same scene, thus we model the 3D geometry consistency by explicitly incorporating the relationship of depth and normal into the training procedure and use the relationship as a regularization in the objective function. The regularization term $L_{dn}(D, N) = 0$ is realized by two layers in our framework: depth2normal layer and normal2depth layer.

Depth2normal layer. The normal direction of each point is computed based on the neighboring points after projecting to 3D space. The process of calculating normal direction of point p is shown in Figure **??**. $\theta(p)$ is a set of neighboring (8) points of p. Take point $q \in \theta(p)$ for example. R_q is a set of points that satisfy the requirement: when projecting to 3D space, for $\hat{q} \in \hat{\theta}(p)$ and for $\hat{r} \in \hat{R}_q$, $(\hat{(q)} - \hat{(p)}) \cdot (\hat{r} - \hat{(p)})) \neq 0)$. Symbols with hat represent corresponding points in 3D space. Theoretically, the cross-product of any two non-collinear (in 3D space) vectors connecting $\hat{p}$ and $\hat{\theta}(p)$ is the normal direction $N(p)$. To reduce the possiblity that the two vectors being collinear in 3D space, we require the vectors to be perpendicular when projected in 2D plane. The normal directions are averaged when iterating $q \in \theta(p)$, and then l_2 normalized to make it a unit vector. The normal direction is calculated as:

$$N(p) = l_2(\sum_{\theta(p)}\sum_{R_q}((\hat{q} - \hat{p}) \times (\hat{r} - \hat{p}))) \quad q \in \theta(p), r \in R_q$$

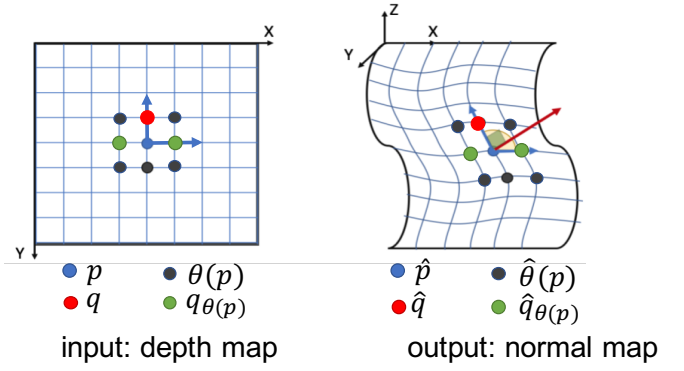for each $q \in \theta(p)$, R_q should satisfy $(q - p) \cdot (r - p) = 0$, $r \in R_q$.

Figure 2: Depth2normal layer. $p, q, \theta(p), q_{\theta(p)}$ are 2D points, and $\hat{p}, \hat{q}, \hat{\theta}(p), \hat{q}_{\theta(p)}$ are corresponding points projected to 3D space.

Normal2depth layer. Normal2depth layer takes depth map and normal map as input and outputs a "shifted" depth map.

4 Evaluation

4.1 Datasets and metrics

4.2 Ablation study

Depth and normal geometry consistency
  Image edge in smoothness term
  Image edge in depth2normal and normal2depth layers
  Image gradient matching

4.3 Comparison with other methods

KITTI 2015 test split
  KITTI 2015 Eigen split

5 Conclusion

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Section Numbers The use of section numbers in AAAI Press papers is optional. To use section numbers in LaTeX, uncomment the setcounter line in your document preamble and change the 0 to a 1 or 2. Section numbers should not be used in short poster papers.

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Acknowledgments. The acknowledgments section, if included, appears after the main body of text and is headed "Acknowledgments." This section includes acknowledgments of help from associates and colleagues, credits to sponsoring agencies, financial support, and permission to publish. Please acknowledge other contributors, grant support, and so forth, in this section. Do not put acknowledgments in a footnote on the first page. If your grant agency requires acknowledgment of the grant on page 1, limit the footnote to the required statement, and put the remaining acknowledgments at the back. Please try to limit acknowledgments to no more than three sentences.

Appendices. Any appendices follow the acknowledgments, if included, or after the main body of text if no acknowledgments appear.

References The references section should be labeled "References" and should appear at the very end of the paper (don't end the paper with references, and then put a figure by itself on the last page). A sample list of references is given later on in these instructions. Please use a consistent format for references. Poorly prepared or sloppy references reflect badly on the quality of your paper and your research. Please prepare complete and accurate citations.

9.20 Illustrations and Figures

Figures, drawings, tables, and photographs should be placed throughout the paper near the place where they are first discussed. Do not group them together at the end of the paper. If placed at the top or bottom of the paper, illustrations may run across both columns. Figures must not invade the top, bottom, or side margin areas. Figures must be inserted using the \usepackage{graphicx}. Number figures sequentially, for example, figure 1, and so on.

The illustration number and caption should appear under the illustration. Labels, and other text with the actual illustration must be at least nine-point type.

If your paper includes illustrations that are not compatible with PDFTEX (such as .eps or .ps documents), you will need to convert them. The epstopdf package will usually work for eps files. You will need to convert your ps files to PDF however.

Low-Resolution Bitmaps. You may not use low-resolution (such as 72 dpi) screen-dumps and GIF files—these files contain so few pixels that they are always blurry, and illegible when printed. If they are color, they will become an indecipherable mess when converted to black and white. This is always the case with gif files, which should never be used. The resolution of screen dumps can be increased by reducing the print size of the original file while retaining the same number of pixels. You can also enlarge files by manipulating them in software such as PhotoShop. Your figures should be 300 dpi when incorporated into your document.

LaTeX Overflow. LaTeX users please beware: LaTeX will sometimes put portions of the figure or table or an equation in the margin. If this happens, you need to scale the figure or table down, or reformat the equation. **Check your log file!** You must fix any overflow into the margin (that means no overfull boxes in LaTeX). If you don't, the overflow text will simply be eliminated. **Nothing is permitted to intrude into the margin or gutter.**

Using Color. Use of color is restricted to figures only. It may never be used for any portion of the text of your paper. The archival version of your paper will be printed in black and white and grayscale. Consequently, because conversion to grayscale can cause undesirable effects (red changes to black, yellow can disappear, and so forth), we strongly suggest you avoid placing color figures in your document. If you do include color figures, you must (1) use the CMYK (not RGB) colorspace and (2) be mindful of readers who may happen to have a color deficiency. Your paper must be decipherable without using color for distinction.

Drawings. We suggest you use computer drawing software (such as Adobe Illustrator or, (if unavoidable), the drawing tools in Microsoft Word) to create your illustrations. Do not use Microsoft Publisher. These illustrations will look best if all line widths are uniform (half- to two-point in size), and you do not create labels over shaded areas. Shading should be 133 lines per inch if possible. Use Times Roman or Helvetica for all figure call-outs. **Do not use hairline width lines** — be sure that the stroke width of all lines is at least .5 pt. Zero point lines will print on a laser printer, but will completely disappear on the high-resolution devices used by our printers.

Photographs and Images. Photographs and other images should be in grayscale (color photographs will not reproduce well; for example, red tones will reproduce as black, yellow may turn to white, and so forth) and set to a minimum of 300 dpi. Do not prescreen images.

Resizing Graphics. Resize your graphics **before** you include them with LaTeX. You may **not** use trim or clip options as part of your \includegraphics command. Resize the media box of your PDF using a graphics program instead.

Fonts in Your Illustrations You must embed all fonts in your graphics before including them in your LaTeX document.

9.21 References

The AAAI style includes a set of definitions for use in formatting references with BibTeX. These definitions make the bibliography style fairly close to the one specified below. To use these definitions, you also need the BibTeX style file "aaai.bst," available in the author kit on the AAAI web site. Then, at the end of your paper but before \enddocument, you need to put the following lines:

\bibliographystyle{aaai} \bibliography{bibfile1,bibfile2,...}

Please note that you are required to use \bibliographystyle{aaai} for your references. You may not use named, plain, apalike, acm, ieeetr, siam, chicago, or any other style. Use of natbib is also not acceptable.

The list of files in the \bibliography command should be the names of your BibTeX source files (that is, the .bib files referenced in your paper).

The following commands are available for your use in citing references:

\cite: Cites the given reference(s) with a full citation. This appears as "(Author Year)" for one reference, or "(Author Year; Author Year)" for multiple references.
\shortcite: Cites the given reference(s) with just the year. This appears as "(Year)" for one reference, or "(Year; Year)" for multiple references.
\citeauthor: Cites the given reference(s) with just the author name(s) and no parentheses.
\citeyear: Cites the given reference(s) with just the date(s) and no parentheses.

Warning: The aaai.sty file is incompatible with the hyperref and natbib packages. If you use either, your references will be garbled and your paper will not be published.

Formatted bibliographies should look like the following examples.

Book with Multiple Authors
Engelmore, R., and Morgan, A. eds. 1986. *Blackboard Systems.* Reading, Mass.: Addison-Wesley.

Journal Article
Robinson, A. L. 1980a. New Ways to Make Microcircuits Smaller. *Science* 208: 1019–1026.

Magazine Article
Hasling, D. W.; Clancey, W. J.; and Rennels, G. R. 1983. Strategic Explanations in Consultation. *The International Journal of Man-Machine Studies* 20(1): 3–19.

Proceedings Paper Published by a Society
Clancey, W. J. 1983. Communication, Simulation, and Intelligent Agents: Implications of Personal Intelligent Machines for Medical Education. In *Proceedings of the Eighth International Joint Conference on Artificial Intelligence,* 556–560. Menlo Park, Calif.: International Joint Conferences on Artificial Intelligence, Inc.

Proceedings Paper Published by a Press or Publisher
Clancey, W. J. 1984. Classification Problem Solving. In *Proceedings of the Fourth National Conference on Artificial Intelligence,* 49–54. Menlo Park, Calif.: AAAI Press.

University Technical Report
Rice, J. 1986. Poligon: A System for Parallel Problem Solving, Technical Report, KSL-86-19, Dept. of Computer Science, Stanford Univ.

Dissertation or Thesis
Clancey, W. J. 1979. Transfer of Rule-Based Expertise through a Tutorial Dialogue. Ph.D. diss., Dept. of Computer Science, Stanford Univ., Stanford, Calif.

Forthcoming Publication
Clancey, W. J. 1986. The Engineering of Qualitative Models. Forthcoming.

10   Some Common Errors to Avoid

The following list includes a number of the most common mistakes made by authors when formatting their paper and the reponses that have been sent to the author regarding them:

PDFINFO
The following required elements are missing from the preamble to your LaTeX source (or are malformed):

```
\pdfinfo{
/Title ()
/Author ()
}
```

A4
The PDF you submitted is A4. All PDFs must be US Letter sized. Submissions that do not conform to this requirement cannot be published.

ABOVEDISPLAY
You've used \abovedisplay, \belowdisplay, \above caption, and \belowcaption to alter aaai18.sty. These commands are illegal and must be stripped from your source.

ABSTRACT INDENTATION
Remove the \begin{quote} and \{endquote} around your abstract. It might buy you some space.

ASPECT RATIO OF FIGURES CHANGED
You may scale the height OR the width of your figures, but not both.

AUTHOR LIST MALFORMED (AUTHBLK)
The authblk.sty package cannot be used.

AUTHOR LIST MALFORMED
You did not use the built-in commands in aaai18.sty to format your authors. You need to follow the formatting instructions for authors using LaTeX.

AUTHOR LIST TOO WIDE
Your author list goes beyond the accepted page width. Please break the line and insert {\bf \Large} around the authors on the second line. The author and title information must be presented as specified in the author instructions.

AUTHOR AFFLIATIONS TOO WIDE
Your author's affiliations go beyond the accepted page width. Please break the line.

BASELINESTRETCH
You've used \baselinestretch — a command specifically prohibited in the author formatting instructions. Please remove it.

CAPTION STYLE ALTERED (CAPTION.STY)
You've altered the font and style of captions. Captions must be rendered as specified by aaai.sty. They cannot be altered by changing the font, fontsize, or position, whether manually or by using caption.sty. Such revisions must be removed.

CJK
The CJK package cannot be used. Restrict use of non-roman alphabets to figures and tables, which must be compiled and converted to PDF, then imported as a figure into LaTeX.

CLIP
You may not use the clip to import only a portion of a graphic. It only places a fragile layer that screens the remained of the figure from view, but imports the entire figure into the PDF. The layer is fragile, and often fails when flattened. The full content of all figures must be imported. In addition and for the same reason, you may not use vspace to reposition a figure. All figures must be completely cropped and adjusted outside of LaTeX before being imported.

COLUMN WIDTH
Unfortunately, your paper contains material that exceeds the column width. Please review your LaTeX log file and correct all the overfull boxes.

COMPILE ERRORS
Unfortunately, the source file you submitted will not compile. We are getting undefined control sequence errors. There are either missing packages in your preamble, or missing definitions, or perhaps you are using an old or modified style. For your information, we are using a complete 2017 install of TeXLive, complete with all updates as of September 1. The packages listed in your preamble are all installed on all our systems. If you are using a style file that is not in that package, you will need to include it. Whatever the reason, we need you to correct your LaTeX and resubmit your source files. (If your paper contains graphics, be certain that the fonts are embedded.)

EPSF / EPSFIG / PSFIG
The epsf, epsfig, and psfig packages are obsolete. Use the graphicx package instead.

EULER
The euler package is obsolte

FIGURES HAVE BEEN CROPPED WITH LATEX
You have used trim and clip commands in your \includegraphics statement. Please crop your graphics appropriately using a standard graphics program (not Preview). The masks created by LaTeX are fragile, and disappear when PDFs are combined together. This will result in text in your paper becoming obscured by the fully restored graphic you have imported.

FIGURES MISSING
Unfortunately, the source file you submitted are incomplete. You did not include the graphics files. As a result, your paper will not compile. You must upload a new compressed archive that contains all the files required to compile your paper on a different computer and network. (If your paper contains graphics, be certain that the fonts are embedded.)

FLOATS ALTERED
You've altered floats. The \renewcommand cannot be used. The float package cannot be used. Please remove them.

FOOTNOTE STYLE ALTERED
Footnotes must follow the built-in style.

FONTS (EMBEDDING)
Unfortunately, one or more of the fonts in your paper (most likely the figures) were not embedded in your PDF. This can cause hidden and silent changes to characters once the paper is published, especially when it is combined with other PDFs in the proceedings. If you need to know how to verify the fonts in your figures, please search for "font embedding pdf." You will find a number of methods, one or more of which may be suitable for your operating system and available software. We recommend using Acrobat Reader to check document properties in your PDF, as it is standards-based software. Consequently, you must embed all the fonts in all your graphics files. If you do not know how to do this, change them to png or jpg.

FONTS (LANGUAGE)
We cannot accept files that require custom installation of non-roman font sets, including CJK and arabic.

FONTS (TYPE 3)
Unfortunately, one or more of the fonts in your paper (most likely the figures) are type 3 PDF. If in your figures, you must either change them to type 1 embedded fonts or change them to png or jpg. If the problem is in your text, you will need to switch the package you are using that is calling type 3 fonts to one that uses type 1 fonts. (Blackboard fonts are often the problem in these cases.)

FULL PAGE USED
You used \usepackage{full page}, which is a package specifically disallowed. You must remove it.

GEOMETRY USED
You used \usepackage{geometry}, which is a package specifically disallowed. You must remove it.

GRAPHICS
The graphics package is obsolete. Use the graphicx package instead.

HYPERREF
The hyperref package may never be used. If you are using it for URLs, use url.sty instead

INCOMPATIBLE SCRIPT OR MACRO
You've used an incompatible script (such as \maltepaper.sty) to automate completion of the title and author information on your paper and in the metadata. Such scripts impede correction of your paper and often are incompatible with Acrobat (producing corrupted metadata fields). Scripts and macros cannot be used to automate population of metadata, author or title information, or insertion of figures or tables.

LAYOUT
The layout package cannot be used. Use url.sty instead.

LINESPREAD
\linespread alters aaai.sty. This command (along with \baselineshift and others that alter aaai.sty) cannot be used. You must remove it.

LMODERN
You used \usepackage{lmodern}, which is a package specifically disallowed. You must remove it.

LAYOUT USED
You used \usepackage{layout}, which is a package specifically disallowed. You must remove it.

MBOX USED FOR FIGURES
You cannot use mboxes to insert figures. They circumvent the spacing requirements for aaai.sty. Use subfigures instead.

MULTIPLE TEX FILES
You did not submit a single .tex file as specified in the instructions. We require this to avoid production errors and to facilitate debugging. The \input command is not allowed in your source. Please combine all your tex files into a single .tex file (references can remain in .bbl or .bib file).

NAMEREF
The nameref package cannot be used.

NATBIB
Natbib is incompatible with aaai18.sty and aaai.bst. It must be removed. See References Malformed below.

PAGE BREAKS
You've included pagebreaks in your final submission. (They are not required before your references accepted final papers and must be removed).

PAGE NUMBERS
Your paper contains page numbers. You need to remove them.

PDFLaTeX NOT USED
Your source will not compile in PDFLaTeX. You must convert your eps graphics to PDF.

PDFCOMMENT
You used pdfcomment, which is a disallowed package. You must remove it.

PSTRICKS
You used pstricks, which is a package specifically disallowed. You must remove it. (Use Tikz instead). If you are simply adding labels, use pinlabel.sty.

REFERENCES ARE INDENTED
You've indented your references. Remove the \begin{quote} and \endquote

REFERENCES MALFORMED
You've used natbib, which is incompatible with aaai.bst.

As an alternate to this, try this workaround:

```
% \usepackage{natbib}
\newcommand{\citet}[1]
{\citeauthor{#1}~\shortcite{#1}}
\newcommand{\citep}{\cite}
\newcommand{\citealp}[1]
{\citeauthor{#1}~\citeyear{#1}}
```

REFERENCES TOO SMALL
Your references are too small. They cannot be any smaller than 9 pt (\small). Please correct this.

SAVETREES
The savetrees may not be used.

SETLENGTH
You've used \setlength to alter textfloats. This command is specifically disallowed. Please strip it from your source and recompile.

SETSPACE
The setspace package may not be used.

SPACE ABOVE, BELOW ELEMENTS ALTERED
You've adjusted the space above or below tables, figures, captions, floats, and/or section/subsection/subsubsections. These changes alter aaai.sty and are not allowed. Please remove them and either edit your text or resize figures or both.

SOURCE FILES MISSING
Your compressed archive does not contain *ALL* your source files (a stand-alone archive containing all the files necessary to recompile your paper in LaTeX). Consequently, your LaTeX file will not compile. You must create another compressed archive in which you have included all the files necessary to compile your paper on a separate computer. We cannot publish your paper without these files.

SPACE ALTERED ABOVE, BELOW FLOATS AND SECTIONS
You've adjusted the space above or below tables, figures, captions, and/or section/subsection/subsubsections. These changes alter aaai.sty and have resulted in a paper that is more difficult to read. Please remove them and either edit your text or resize figures or both.

STYLE FILE OF BIBLIOGRAPHY IS INCORRECT
You did not use aaai.bst (you used named.bst instead). This is not an IJCAI conference. You need to recompile your bibliography using the correct style for AAAI-18.

STYLE FILE IS INCORRECT
You did not use aaai18.sty. This style file is required. No other style file (including previous versions of aaai.sty) may be used.

STYLE FILE NOT IN CTAN
All styles must be available in the CTAN archive. If they are custom, you need to remove them and put the contents of the custom style directly in your preamble so that our source checker will allow compilation of your file.

TIMES PACKAGE NOT USED
Your paper is not formatted using the Times package, either because it is missing completely from your preamble, or because you are using another package that is cancelling use of times. This package is required.

TITLESEC
The title sec package may not be used.

VSPACE USED
You've used negative vspace around section / subsections. These must be removed.

TIMES PACKAGE MISSING
You neglected to use \usepackage{times}. This font is required.

TITLE AND AUTHOR INFORMATION MALFORMED
You need to remove the formatting commands from your title and author information. The style for this information is governed by the conference style file. It cannot be altered.

TITLE BOX TOO SMALL
Your author-title-affiliation data exceeds the limit of the title box. To fix this, you need to increase the size of the title box. You can do this by placing \setlength\titlebox{2.5in} in your preamble. You may need to increase the measurement until the log file error goes away. (Please note: This command cannot be used elsewhere in the paper, and cannot be used to shrink the size of the title box.)

TITLE IN SENTENCE CASE
Your title is formatted in sentence case. Title Case (Mixed Case) is required. Please capitalize the initial letters of all words in your title except for conjunctions and prepositions. You need to do this in your source, in the \pdfinfo in your source, and on the submission website.

TITLE MALFORMED (TITLESEC)
You've used titlesec.sty, which alters the AAAI style. It must be removed.

TOCBIBIND
The tocbibind package may not be used.

ULEM
The ulem package may not be used.

T1ENC
The T1enc package is obsolete. Us the CM Super Fonts package instead.

11 Producing Reliable PDF Documents with LaTeX

Generally speaking, PDF files are platform independent and accessible to everyone. When creating a paper for a proceedings or publication in which many PDF documents must be merged and then printed on high-resolution PostScript RIPs, several requirements must be met that are not normally of concern. Thus to ensure that your paper will look like it does when printed on your own machine, you must take several precautions:

- Use type 1 fonts (not type 3 fonts)
- Use only standard Times, Nimbus, and CMR font packages (not fonts like F3 or fonts with tildes in the names or fonts—other than Computer Modern—that are created for specific point sizes, like Times~19) or fonts with strange combinations of numbers and letters
- Embed all fonts when producing the PDF
- Do not use the [T1]fontenc package (install the CM super fonts package instead)

11.1 Creating Output Using PDFLATEX Is Required

By using the PDFTEX program instead of straight LATEX or TEX, you will probably avoid the type 3 font problem altogether (unless you use a package that calls for metafont). PDFLATEX enables you to create a PDF document directly from LATEX source. The one requirement of this software is that all your graphics and images must be available in a format that PDFLATEX understands (normally PDF, jpg, or png).

PDFLATEX's default is to create documents with type 1 fonts. If you find that it is not doing so in your case, it is likely that one or more fonts are missing from your system or are not in a path that is known to PDFLATEX.

dvipdf Script Scripts such as dvipdf which ostensibly bypass the Postscript intermediary should not be used since they generally do not instruct dvips to use the config.pdf file.

dvipdfm Do not use this dvi-PDF conversion package.

11.2 Ghostscript

LATEX users should not use GhostScript to create their PDFs.

11.3 Graphics

If you are still finding type 3 fonts in your PDF file, look at your graphics! LATEX users should check all their imported graphics files as well for font problems.

12 Proofreading Your PDF

Please check all the pages of your PDF file. Is the page size A4? Are there any type 3, Identity-H, or CID fonts? Are all the fonts embedded? Are there any areas where equations or figures run into the margins? Did you include all your figures? Did you follow mixed case capitalization rules for your title? Did you include a copyright notice? Do any of the pages scroll slowly (because the graphics draw slowly on the page)? Are URLs underlined and in color? You will need to fix these common errors before submitting your file.

13 Improperly Formatted Files

In the past, AAAI has corrected improperly formatted files submitted by the authors. Unfortunately, this has become an increasingly burdensome expense that we can no longer absorb. Consequently, if your file is improperly formatted, it will not be included in the publication. If time allows, however, you will be notified via e-mail of the problems with your file and given the option of correcting the file yourself. A resubmission fee (minimum $50.00, and likely higher) will be required for this service). Optionally, you may ask that AAAI have the file corrected for you, for an additional fee. If you opt to correct the file yourself, please note that we cannot provide you with any additional advice beyond that given in your packet. Files that are not corrected after a second attempt will not be included in the publication.

13.1 LATEX 209 Warning

If you use LATEX 209 we will not be able to publish your paper. Convert your paper to LATEX2e.

14 Naming Your Electronic File

We request that you name your LATEX source file with your last name (family name) so that it can easily be differentiated from other submissions. If you name your files with the name of the event or "aaai" or "paper" or "camera-ready" or some other generic or indecipherable name, you bear all risks of loss — it is extremely likely that your file may be overwritten.

15 Submitting Your Electronic Files to AAAI

Submitting your files to AAAI is a two-step process. It is explained fully in the author registration and submission instructions. Please consult this document for details on how to submit your paper.

16 Inquiries

If you have any questions about the preparation or submission of your paper as instructed in this document, please contact AAAI Press at the address given below. If you have technical questions about implementation of the aaai style file, please contact an expert at your site. We do not provide technical support for LATEX or any other software package. To avoid problems, please keep your paper simple, and do not incorporate complicated macros and style files.

AAAI Press
2275 East Bayshore Road, Suite 160
Palo Alto, California 94303
Telephone: (650) 328-3123
E-mail: See the submission instructions for your particular conference or event.

17 Additional Resources

LATEX is a difficult program to master. If you've used that software, and this document didn't help or some items were not explained clearly, we recommend you read Michael Shell's excellent document (testflow doc.txt V1.0a 2002/08/13) about obtaining correct PS/PDF output on LATEX systems. (It was written for another purpose, but it has general application as well). It is available at www.ctan.org in the tex-archive.

18 Acknowledgments

Thank you for reading these instructions carefully. We look forward to receiving your electronic files!