LaTeX Author Guidelines for CVPR Proceedings

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Abstract

Federated Learning (FL) has emerged as a paradigm for training machine learning models across distributed clients without sharing raw data. Despite its promise, FL faces challenges due to statistical heterogeneity (non-IID client data) and system heterogeneity (variable resources and participation). This paper presents a systematic study of these challenges through experiments on CIFAR-100 and Shakespeare datasets, implementing centralized and federated baselines with varying degrees of heterogeneity. We analyze the impact of client participation patterns and non-IID data distributions on FedAvg performance. Finally, inspired by prior work on client selection, we propose diversity-aware selection strategies based on label distribution entropy, inter-client distance, and local loss values, showing improved convergence under heterogeneous conditions.

1. Introduction

1.1. Federated Learning and its Challenges

Federated learning is a machine learning approach where many clients collaboratively train a model under the coordination of a central server [6]. The main advantage is that the raw data remains on the client devices, preserving privacy and reducing the need to transfer sensitive information. Only model updates are sent to the server.

However, federated learning also introduces new challenges. As the number of participating devices grows, communication between the clients and the server can become a significant bottleneck. Another challenge is that client data, such as that collected from mobile phones, is often non-IID (not independent and identically distributed) and unbalanced, since it depends on how each user interacts with their device.

1.2. Baselines and personal contributions

[In this paper we analyze the standard FL scenarios, comparing a centralized baseline with a federated one. We also study the impact of client participation (uniform vs. skewed) as well as the effects of heterogeneous data distributions on the federated baseline. Since we noticed that these two aspects are critical for effective federated learning, we then propose two client selection strategies that can mitigate these challenges.]

We began by analyzing a centralized baseline to evaluate the performance of the chosen model and to compare it with the federated setting. We also examined different schedulers to determine which yielded faster and more reliable results. We set up a federated baseline and used it to study the impact of client participation (uniform vs. skewed) as well as the effects of heterogeneous data distributions. Our personal contributions focus on client selection policies that better account for variability in both client usefulness (their impact on training) and data diversity.

The first contribution studies minibatch probing as a mechanism to estimate the near-term impact of candidate clients. Probing identifies clients that are likely to produce large, informative updates, thereby accelerating convergence. However, a purely probe-driven top-k selection tends to starve "weak" clients. To counter this, we introduce a probe + fairness hybrid, blending probe utility with fairness-aware scheduling that tracks participation frequency and recency. This ensures that all clients (also those with limited or skewed data) remain represented in training, balancing short-term efficiency with long-term equity. The second contribution introduces a Diversity Score Sampling to limit redundant updates from clients with similar data. We define a diversity score that combines intra-client diversity (label coverage and distribution balance) with inter-client diversity (dissimilarity to other clients). This score favors clients whose participation provides novel information while reducing redundancy.

2. Conclusion

This paper provided studies on minibatch probing as a mechanism to estimate the near-term impact of candidate clients. Probing identifies clients that are likely to produce large, informative updates, thereby accelerating convergence. However we saw that a purely probe-driven top-k selection tends to starve "weak" clients. To counter this, we

introduced a probe + fairness hybrid, blending probe utility with fairness-aware scheduling that tracks participation frequency and recency. This ensures that all clients (also those with limited or skewed data) remain represented in training, balancing short-term efficiency with long-term equity. The second contribution, instead, introduced a Diversity Score Sampling to limit redundant updates from clients with similar data. We defined a diversity score that combines intra-client diversity (label coverage and distribution balance) with inter-client diversity (dissimilarity to other clients). This score favors clients whose participation provided novel information while reducing redundancy. By this 2 contributions we tackled the challenges of statistical heterogeneity and skewed participation in federated learning, improving convergence and model performance.

3. Methodologies

3.1. Datasets

We use two datasets to evaluate our methods: CIFAR-100 and Shakespeare. CIFAR-100 [8] is an image classification dataset consisting of 60,000 32x32 color images in 100 classes, with 600 images. Shakespeare [5] is a text dataset derived from the works of Shakespeare, used for next-character prediction tasks. Each sample is comprised of a text of 80 characters (x), a next character (y) and a label which contains info about the play title and the character name that is telling the line .

3.2. Splits

In CIFAR-100 examples are already split between train(50000 samples) and test(10000 samples). To get the validation set we randomly sampled 5000 samples from the training set. We ended up with 45000 samples for training, 5000 for validation and 10000 for testing. In Shakespeare, we split using 90% of the samples for training, 5% for validation, and 5% for testing.

3.3. Baseline

We implemented a centralized baseline model for both datasets in order to provide a performance reference. For CIFAR-100, we adopted a convolutional neural network inspired by the LeNet architecture consisting in two convolutional layers with ReLU activations and max-pooling operations, followed by three fully connected layers. The final layer outputs logits over the 100 classes. For the Shakespeare dataset, we employed a character-level recurrent neural network which consists of an embedding layer, a two-layer Long Short-Term Memory(LSTM) with dropout, and a linear output layer with output dimension equal to the vocabulary size. Given a sequence of characters, it predicts the next character at the sequence end.

Training on CIFAR and on Shakespeare was performed using cross-entropy loss and stochastic gradient descent, updating parameters via backpropagation .

3.4. FedAvg

For federated learning we used FedAvg [7] .It consists of a server and multiple clients. The server initializes a global model and sends it to a subset of clients (in case 10% of them).In our case we considered we had 100 clients. Each client trains the model on its local data for a few steps and sends the updated model back to the server. The server then aggregates the updates by averaging to form a new global model, which is sent back to the clients for the next round of training. This process is repeated for a specified number of steps. For test with J value(number of local steps) we set up a budget of 8000 for cifar and 2000 for shakespeare. This means that the total number of local steps multiplied by number of global rounds should not exceed the budget.

3.5. heterogeneity

To replicate the heterogeneity of real-world federated learning scenarios, we introduced heterogenity by limiting the number of classes per client. The parameter Nc indicates the number of classes assigned to each client. For Cifar we used class of the images to do the split , for shakespeare we created a custom dataset where class is a character of a play , so we assigned togheder also same characters from different plays.

3.6. Skeweness

To replicate real-world federated learning scenarios, we also analyzed the impact of skewed client participation. Using a Dirichlet distribution with parameter gamma, we generated non-uniform client participation probabilities. A smaller gamma value results in a more skewed distribution, where a few clients are selected more frequently than others.

4. Experiments

4.1. Schedulers

We've tested different schedulers for the centralized baseline to find the one that gives the best performance. We tested StepLR, MultiStepLR, ReduceLROnPlateau, ExponentialLR, OneCycleLR, CosineAnnealingLR and CosineAnnealingWarmRestarts, each one set up with reasonable parameters that can be found in the code . The best one turned out to be OneCycleLR for Cifar to get to a better result in few steps and also to get the best result at the end of 500 epochs.

For Shakespeare the best one after 50 rounds turned out to be ReduceLROnPlateau.
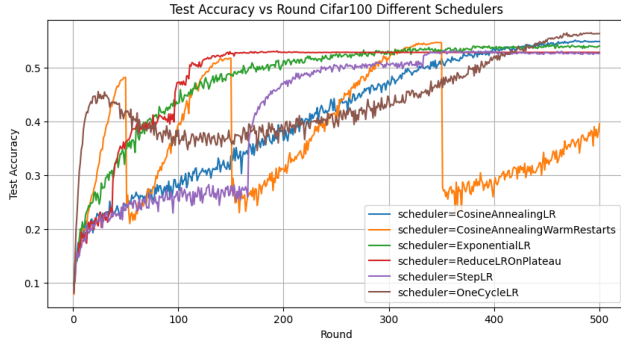
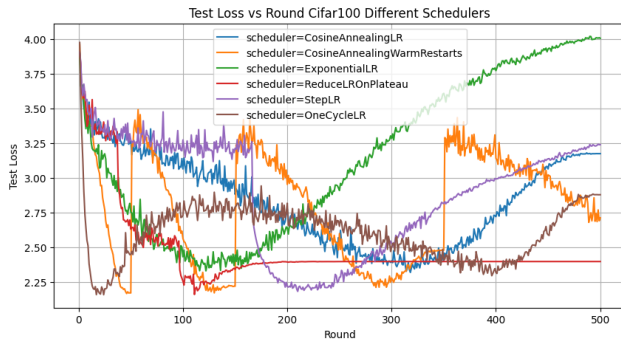Figure 1. Comparison between different schedulers on CIFAR dataset.

Figure 2. Comparison between different schedulers loss on Shakespeare dataset.
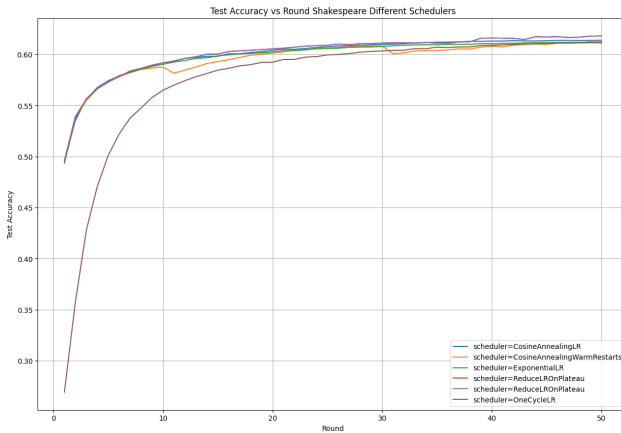

Figure 3. Comparison between different schedulers on Shakespeare dataset.

There isn't a big difference between different schedulers max accuracy anyway , max difference is around 1% for shakespeare and 5% for cifar.
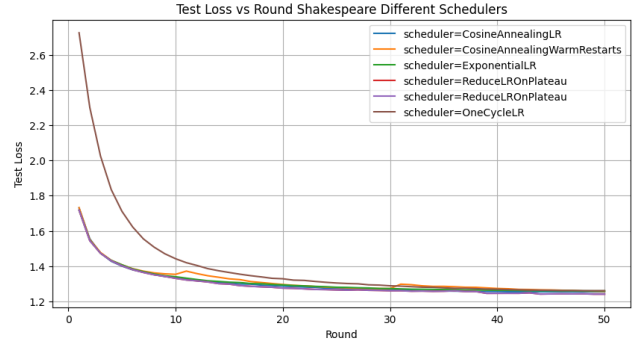

Figure 4. Comparison between different schedulers loss on Shakespeare dataset.

5. Placeholder

5.1. Paper length

Papers, excluding the references section, must be no longer than eight pages in length. The references section will not be included in the page count, and there is no limit on the length of the references section. For example, a paper of eight pages with two pages of references would have a total length of 10 pages. **There will be no extra page charges for CVPR 2022.**

Overlength papers will simply not be reviewed. This includes papers where the margins and formatting are deemed to have been significantly altered from those laid down by this style guide. Note that this LaTeX guide already sets figure captions and references in a smaller font. The reason such papers will not be reviewed is that there is no provision for supervised revisions of manuscripts. The reviewing process cannot determine the suitability of the paper for presentation in eight pages if it is reviewed in eleven.

5.2. The ruler

The LaTeX style defines a printed ruler which should be present in the version submitted for review. The ruler is provided in order that reviewers may comment on particular lines in the paper without circumlocution. If you are preparing a document using a non-LaTeX document preparation system, please arrange for an equivalent ruler to appear on the final output pages. The presence or absence of the ruler should not change the appearance of any other content on the page. The camera-ready copy should not contain a ruler. (LaTeX users may use options of cvpr.sty to switch between different versions.)

Reviewers: note that the ruler measurements do not align well with lines in the paper — this turns out to be very difficult to do well when the paper contains many figures and equations, and, when done, looks ugly. Just use fractional references (*e.g.*, this line is 087.5), although in most cases one would expect that the approximate location will be ad-

equate.

5.3. Paper ID

Make sure that the Paper ID from the submission system is visible in the version submitted for review (replacing the "*****" you see in this document). If you are using the LATEX template, **make sure to update paper ID in the appropriate place in the tex file**.

5.4. Mathematics

Please number all of your sections and displayed equations as in these examples:

$$E = m \cdot c^2 \tag{1}$$

and

$$v = a \cdot t. \tag{2}$$

It is important for readers to be able to refer to any particular equation. Just because you did not refer to it in the text does not mean some future reader might not need to refer to it. It is cumbersome to have to use circumlocutions like "the equation second from the top of page 3 column 1". (Note that the ruler will not be present in the final copy, so is not an alternative to equation numbers). All authors will benefit from reading Mermin's description of how to write mathematics: http://www.pamitc.org/documents/mermin.pdf.

5.5. Blind review

Many authors misunderstand the concept of anonymizing for blind review. Blind review does not mean that one must remove citations to one's own work—in fact it is often impossible to review a paper unless the previous citations are known and available.

Blind review means that you do not use the words "my" or "our" when citing previous work. That is all. (But see below for tech reports.)

Saying "this builds on the work of Lucy Smith [1]" does not say that you are Lucy Smith; it says that you are building on her work. If you are Smith and Jones, do not say "as we show in [7]", say "as Smith and Jones show in [7]" and at the end of the paper, include reference 7 as you would any other cited work.

An example of a bad paper just asking to be rejected:

> An analysis of the frobnicatable foo filter.
>
> In this paper we present a performance analysis of our previous paper [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.
>
> [1] Removed for blind review

An example of an acceptable paper:

> An analysis of the frobnicatable foo filter.
>
> In this paper we present a performance analysis of the paper of Smith *et al*. [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.
>
> [1] Smith, L and Jones, C. "The frobnicatable foo filter, a fundamental contribution to human knowledge". Nature 381(12), 1-213.

If you are making a submission to another conference at the same time, which covers similar or overlapping material, you may need to refer to that submission in order to explain the differences, just as you would if you had previously published related work. In such cases, include the anonymized parallel submission [9] as supplemental material and cite it as

> [1] Authors. "The frobnicatable foo filter", F&G 2014 Submission ID 324, Supplied as supplemental material fg324.pdf.

Finally, you may feel you need to tell the reader that more details can be found elsewhere, and refer them to a technical report. For conference submissions, the paper must stand on its own, and not *require* the reviewer to go to a tech report for further details. Thus, you may say in the body of the paper "further details may be found in [10]". Then submit the tech report as supplemental material. Again, you may not assume the reviewers will read this material.

Sometimes your paper is about a problem which you tested using a tool that is widely known to be restricted to a single institution. For example, let's say it's 1969, you have solved a key problem on the Apollo lander, and you believe that the CVPR70 audience would like to hear about your solution. The work is a development of your celebrated 1968 paper entitled "Zero-g frobnication: How being the only people in the world with access to the Apollo lander source code makes us a wow at parties", by Zeus *et al*.

You can handle this paper like any other. Do not write "We show how to improve our previous work [Anonymous, 1968]. This time we tested the algorithm on a lunar lander [name of lander removed for blind review]". That would be silly, and would immediately identify the authors. Instead write the following:

> We describe a system for zero-g frobnication. This system is new because it handles the following cases: A, B. Previous systems [Zeus et al. 1968] did not handle case B properly. Ours handles it by including a foo term in the bar integral.
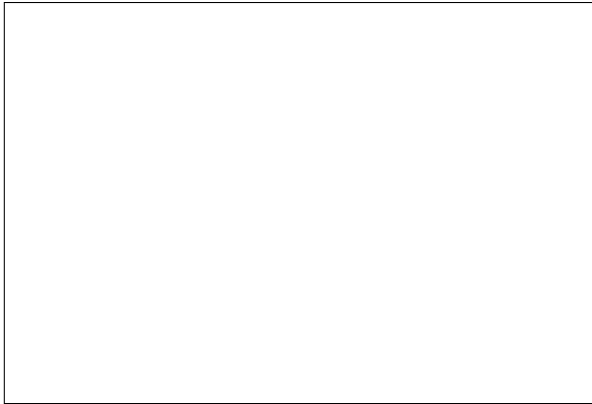>
> ...

Figure 5. Example of caption. It is set in Roman so that mathematics (always set in Roman: $B \sin A = A \sin B$) may be included without an ugly clash.

> The proposed system was integrated with the Apollo lunar lander, and went all the way to the moon, don't you know. It displayed the following behaviours, which show how well we solved cases A and B: ...

As you can see, the above text follows standard scientific convention, reads better than the first version, and does not explicitly name you as the authors. A reviewer might think it likely that the new paper was written by Zeus *et al.*, but cannot make any decision based on that guess. He or she would have to be sure that no other authors could have been contracted to solve problem B.

FAQ

Q: Are acknowledgements OK?
A: No. Leave them for the final copy.

Q: How do I cite my results reported in open challenges?
A: To conform with the double-blind review policy, you can report results of other challenge participants together with your results in your paper. For your results, however, you should not identify yourself and should not mention your participation in the challenge. Instead present your results referring to the method proposed in your paper and draw conclusions based on the experimental comparison to other results.

5.6. Miscellaneous

Compare the following:

`$conf_a$`	$conf_a$
`$\mathit{conf}_a$`	$conf_a$

See The TeXbook, p165.

The space after *e.g.*, meaning "for example", should not be a sentence-ending space. So *e.g.* is correct, *e.g.* is not. The provided `\eg` macro takes care of this.

When citing a multi-author paper, you may save space by using "et alia", shortened to "*et al.*" (not "*et. al.*" as "*et*" is a complete word). If you use the `\etal` macro provided, then you need not worry about double periods when used at the end of a sentence as in Alpher *et al.* However, use it only when there are three or more authors. Thus, the following is correct: "Frobnication has been trendy lately. It was introduced by Alpher [1], and subsequently developed by Alpher and Fotheringham-Smythe [2], and Alpher *et al.* [3]."

This is incorrect: "... subsequently developed by Alpher *et al.* [2] ..." because reference [2] has just two authors.

6. Formatting your paper

All text must be in a two-column format. The total allowable size of the text area is $6\frac{7}{8}$ inches (17.46 cm) wide by $8\frac{7}{8}$ inches (22.54 cm) high. Columns are to be $3\frac{1}{4}$ inches (8.25 cm) wide, with a $\frac{5}{16}$ inch (0.8 cm) space between them. The main title (on the first page) should begin 1 inch (2.54 cm) from the top edge of the page. The second and following pages should begin 1 inch (2.54 cm) from the top edge. On all pages, the bottom margin should be $1\frac{1}{8}$ inches (2.86 cm) from the bottom edge of the page for 8.5×11-inch paper; for A4 paper, approximately $1\frac{5}{8}$ inches (4.13 cm) from the bottom edge of the page.

6.1. Margins and page numbering

All printed material, including text, illustrations, and charts, must be kept within a print area $6\frac{7}{8}$ inches (17.46 cm) wide by $8\frac{7}{8}$ inches (22.54 cm) high. Page numbers should be in the footer, centered and $\frac{3}{4}$ inches from the bottom of the page. The review version should have page numbers, yet the final version submitted as camera ready should not show any page numbers. The LaTeX template takes care of this when used properly.

6.2. Type style and fonts

Wherever Times is specified, Times Roman may also be used. If neither is available on your word processor, please use the font closest in appearance to Times to which you have access.
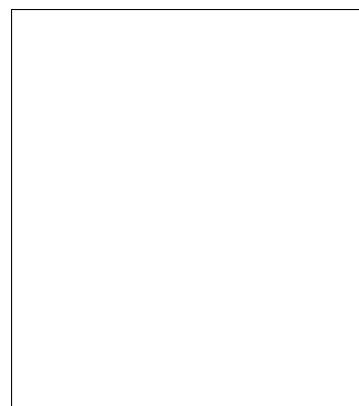
MAIN TITLE. Center the title $1\frac{3}{8}$ inches (3.49 cm) from the top edge of the first page. The title should be in Times 14-point, boldface type. Capitalize the first letter of nouns, pronouns, verbs, adjectives, and adverbs; do not capitalize articles, coordinate conjunctions, or prepositions (unless the title begins with such a word). Leave two blank lines after the title.

AUTHOR NAME(s) and AFFILIATION(s) are to be centered beneath the title and printed in Times 12-point, non-boldface type. This information is to be followed by two blank lines.

The ABSTRACT and MAIN TEXT are to be in a two-column format.
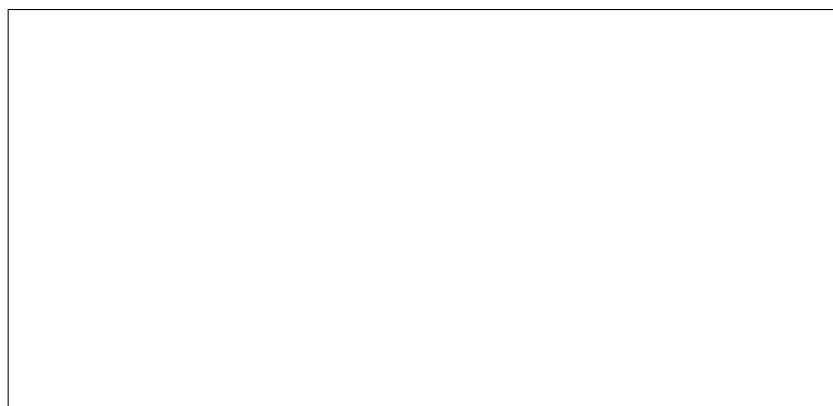
(a) An example of a subfigure. (b) Another example of a subfigure.

Figure 6. Example of a short caption, which should be centered.

MAIN TEXT. Type main text in 10-point Times, single-spaced. Do NOT use double-spacing. All paragraphs should be indented 1 pica (approx. $\frac{1}{6}$ inch or 0.422 cm). Make sure your text is fully justified—that is, flush left and flush right. Please do not place any additional blank lines between paragraphs.

Figure and table captions should be 9-point Roman type as in Figs. 5 and 6. Short captions should be centred. Callouts should be 9-point Helvetica, non-boldface type. Initially capitalize only the first word of section titles and first-, second-, and third-order headings.

FIRST-ORDER HEADINGS. (For example, **1. Introduction**) should be Times 12-point boldface, initially capitalized, flush left, with one blank line before, and one blank line after.

SECOND-ORDER HEADINGS. (For example, **1.1. Database elements**) should be Times 11-point boldface, initially capitalized, flush left, with one blank line before, and one after. If you require a third-order heading (we discourage it), use 10-point Times, boldface, initially capitalized, flush left, preceded by one blank line, followed by a period and your text on the same line.

6.3. Footnotes

Please use footnotes[1] sparingly. Indeed, try to avoid footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence). If you wish to use a footnote, place it at the bottom of the column on the page on which it is referenced. Use Times 8-point type, single-spaced.

6.4. Cross-references

For the benefit of author(s) and readers, please use the

```
\cref{...}
```

command for cross-referencing to figures, tables, equations, or sections. This will automatically insert the appropriate label alongside the cross-reference as in this example:

To see how our method outperforms previous work, please see Fig. 5 and Tab. 1. It is also possible to refer to multiple targets as once, *e.g.* to Figs. 5 and 6a. You may also return to Sec. 6 or look at Eq. (2).

If you do not wish to abbreviate the label, for example at the beginning of the sentence, you can use the

```
\Cref{...}
```

command. Here is an example:

Figure 5 is also quite important.

6.5. References

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example [9]. Where appropriate, include page numbers and the name(s) of editors of referenced books. When you cite multiple papers at once, please make sure that you cite them in numerical order like this [1,2,4,9,10]. If you use the template as advised, this will be taken care of automatically.

6.6. Illustrations, graphs, and photographs

All graphics should be centered. In LATEX, avoid using the `center` environment for this purpose, as this adds potentially unwanted whitespace. Instead use

```
\centering
```

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[1]This is what a footnote looks like. It often distracts the reader from the main flow of the argument.

Method	Frobnability
Theirs	Frumpy
Yours	Frobbly
Ours	Makes one's heart Frob

Table 1. Results. Ours is better.

at the beginning of your figure. Please ensure that any point you wish to make is resolvable in a printed copy of the paper. Resize fonts in figures to match the font in the body text, and choose line widths that render effectively in print. Readers (and reviewers), even of an electronic copy, may choose to print your paper in order to read it. You cannot insist that they do otherwise, and therefore must not assume that they can zoom in to see tiny details on a graphic.

When placing figures in LaTeX, it's almost always best to use \includegraphics, and to specify the figure width as a multiple of the line width as in the example below

```
\usepackage{graphicx} ...
\includegraphics[width=0.8\linewidth]
                {myfile.pdf}
```

6.7. Color

Please refer to the author guidelines on the CVPR 2022 web page for a discussion of the use of color in your document.

If you use color in your plots, please keep in mind that a significant subset of reviewers and readers may have a color vision deficiency; red-green blindness is the most frequent kind. Hence avoid relying only on color as the discriminative feature in plots (such as red *vs*. green lines), but add a second discriminative feature to ease disambiguation.

7. Final copy

You must include your signed IEEE copyright release form when you submit your finished paper. We MUST have this form before your paper can be published in the proceedings.

Please direct any questions to the production editor in charge of these proceedings at the IEEE Computer Society Press: https://www.computer.org/about/contact.

References

[1] FirstName Alpher. Frobnication. *IEEE TPAMI*, 12(1):234–778, 2002. 5, 6

[2] FirstName Alpher and FirstName Fotheringham-Smythe. Frobnication revisited. *Journal of Foo*, 13(1):234–778, 2003. 5, 6

[3] FirstName Alpher, FirstName Fotheringham-Smythe, and FirstName Gamow. Can a machine frobnicate? *Journal of Foo*, 14(1):234–778, 2004. 5

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[8] Alex Krizhevsky. Learning multiple layers of features from tiny images. 2009. 2

[9] FirstName LastName. The frobnicatable foo filter, 2014. Face and Gesture submission ID 324. Supplied as supplemental material fg324.pdf. 4, 6

[10] FirstName LastName. Frobnication tutorial, 2014. Supplied as supplemental material tr.pdf. 4, 6