# Machine Learning Project - Fall 2023

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## Abstract

*The ABSTRACT is to be in fully justified italicized text, at the top of the left-hand column, below the author and affiliation information. Use the word "Abstract" as the title, in 12-point Times, boldface type, centered relative to the column, initially capitalized. The abstract is to be in 10-point, single-spaced type. Leave two blank lines after the Abstract, then begin the main text. Look at previous CVPR abstracts to get a feel for style and length.*

## 1. Introduction

Please follow the steps outlined below when submitting your manuscript to the IEEE Computer Society Press. This style guide now has several important modifications (for example, you are no longer warned against the use of sticky tape to attach your artwork to the paper), so all authors should read this new version.

### 1.1. Semi- Supervised Learning

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.** In semi-supervised learning, the objective function can be defined as: 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.

### 1.2. MNIST Dataset

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**.

### 1.3. Two-Moon Dataset

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

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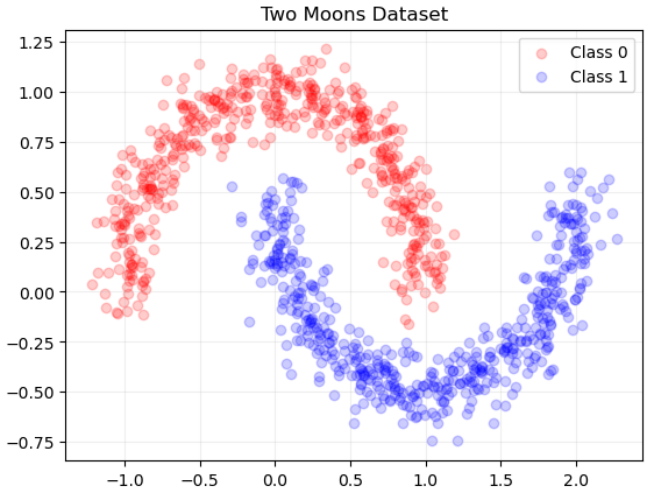
### 1.4. Miscelleanous

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 [4] 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`.

## 2. Models

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 $8.5 \times 11$-inch paper;




(a) Two Moons Dataset.

(b) MNIST Dataset.

Figure 1. Examples of the Datasets being used for the experiment.

for A4 paper, approximately $1\frac{5}{8}$ inches (4.13 cm) from the bottom edge of the page.

### 2.1. Baseline

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### 2.2. Entropy Optimization

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 [4]. [1–5]. If you use the template as advised, this will be taken care of automatically.

The equation for optimizing entropy is given by:

$$\max_{p(x)} \quad H(X) = -\sum_{i=1}^{n} p(x_i) \log(p(x_i)) \tag{1}$$

where:

$H(X)$ is the entropy of the random variable $X$.
$p(x_i)$ is the probability of outcome $x_i$.
$n$ is the number of possible outcomes.

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

### 2.3. Pseudo Label Technique

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

```
\centering
```

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. 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. The pseudo-labeling equation is given by:

$$L'(\theta) = \sum_{i=1}^{n} (L_i(\theta) + \alpha \cdot \mathbb{I}(i \in U) \cdot \log(p_i)) \qquad (2)$$

where:

$L'(\theta)$ is the modified loss function, pseudo-labels.

$L_i(\theta)$ is the loss on the labeled example $i$.

$\alpha$ is a hyperparameter weighting the pseudo-labeling term.

$\mathbb{I}(i \in U)$ $i$ is unlabeled, else 0.

$p_i$ is the predicted probability of the example

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

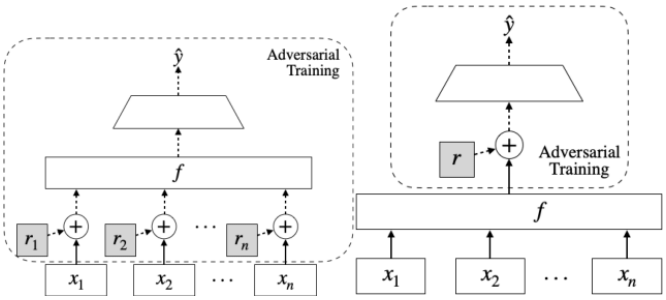


Figure 2. The figure shows a block diagram of the components of VAT

### 2.4. Virtual Adversarial Training

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.

### 2.5. My Novel Method

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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.

Table 1. An 8x3 Table

| **Model Name** | **Training Error** 2 | **Testing Error** |
|---|---|---|
| Baseline | 92.45 | 75.22 |
| Entropy Optimization | 87.22 | 82.38 |
| Adversarial Training | 91.23 | 89.67 |
| Pseudo Label | 96.89 | 93.88 |
| My Technique | 95 | 96.99 |

## 3. Experiments and Results

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### 3.1. Baseline Vs VAT

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### 3.2. Baseline Vs PseudoLabeling

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### 3.3. Overall Comparisons

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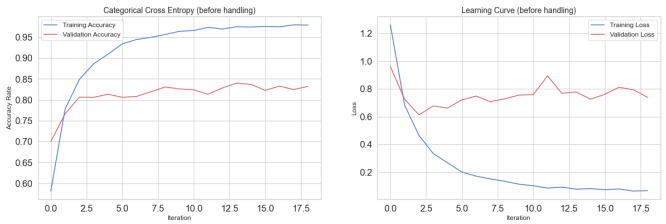


Figure 3. Results of Novel Technique Against the Rest

## 4. Conclusions

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## References


[1] FirstName Alpher. Frobnication. *IEEE TPAMI*, 12(1):234–778, 2002. 2

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

[3] FirstName Alpher and FirstName Gamow. Can a computer frobnicate? In *CVPR*, pages 234–778, 2005. 2

[4] FirstName LastName. The frobnicatable foo filter, 2014. Face and Gesture submission ID 324. Supplied as supplemental material `fg324.pdf`. 1, 2

[5] FirstName LastName. Frobnication tutorial, 2014. Supplied as supplemental material `tr.pdf`. 2