2017 Formatting Instructions for Authors Using LaTeX

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Abstract

The Proposed S Distance

We consider the one dimensional case as a start, where x_r are real samples sampled from distribution $\mathbb{P}_r$, and x_g are generated samples sampled from distribution $\mathbb{P}_g$,

$$x_r \sim \mathbb{P}_r \tag{1}$$

$$x_g \sim \mathbb{P}_g \tag{2}$$

Note that both x_r and x_g are normalized between $[0, 1]$. For every x_r, x_g pair, we sample x_τ between x_r and x_g,

$$x_\tau = \tau x_r + (1 - \tau) x_g \tag{3}$$

where

$$\tau \sim U[0, 1] \tag{4}$$

Assuming x_τ follows a distribution given by $\mathbb{P}_\tau$,

$$x_\tau \sim \mathbb{P}_\tau \tag{5}$$

Apparently, $\mathbb{P}_\tau$ is related to x_r and x_g. Here, we can impose a way to make $\mathbb{P}_\tau$ independent from x_r and x_g, we will discuss this impose method latter, we assume the $\mathbb{P}_\tau$ here is independent from x_r and x_g, and it is uniform on x space.

Following is the optimal S distance proposed in place of Wasserstein distance,

$$S^*(\mathbb{P}_r, \mathbb{P}_g) = \mathbb{E}_{x_\tau \sim \mathbb{P}_\tau}\{|\int_{x_\tau}^{1} \mathbb{P}_r(x')dx' - \int_{x_\tau}^{1} \mathbb{P}_g(x')dx'|\} \tag{6}$$

while the optimal Wasserstein distance is,

$$W^*(\mathbb{P}_r, \mathbb{P}_g) = \sup_{\|f\|_L \leq 1} \{\mathbb{E}_{x_r \sim \mathbb{P}_r}[f(x_r)] - \mathbb{E}_{x_g \sim \mathbb{P}_g}[f(x_g)]\} \tag{7}$$

Apparently, both S^* and W^* distance will be minimized if the $\mathbb{P}_r$ and $\mathbb{P}_g$ are exactly same. To take a deeper insight of the advantage of the proposed S^* distance, we consider the representation of these two distance at each x. This is crucial, since when updating generative model, it only observe the distance at a specific x_g instead of having a whole sight of the distributions $\mathbb{P}_r$ and $\mathbb{P}_g$. The S^* at x is,

$$S^*_{\mathbb{P}_r, \mathbb{P}_g}(x) = |\int_{x}^{1} \mathbb{P}_r(x')dx' - \int_{x}^{1} \mathbb{P}_g(x')dx'| \tag{8}$$

while the Wasserstein distance at x is,

$$W^*_{\mathbb{P}_r, \mathbb{P}_g}(x) = f(x) = \mathbb{P}_r(x) - \mathbb{P}_g(x) \tag{9}$$

We can see that $S^*_{\mathbb{P}_r, \mathbb{P}_g}(x)$ consider than how unbalance are the two distributions in a whole sight, while the $W^*_{\mathbb{P}_r, \mathbb{P}_g}(x)$ considers the unbalance of the two distributions only at this point.

Impose $\mathbb{P}_\tau$ to be independent from x_r and x_g

Consider our problem on a discrete space with interval of ε, we give every notation of x a check mark, i.e., $\check{x}$ to mark that they are discrete value by ε. Later on we will derive its limitation to have a general conclusion on the continuous space. If we sample $\check{x}_\tau$ between $\check{x}_r$ and $\check{x}_g$ for 1 time,

$$d = |\check{x}_r - \check{x}_g| \tag{10}$$

$$P(\check{x}_\tau \overset{1}{=} \check{x}_n | \check{x}_r, \check{x}_g) = \begin{cases} \frac{1}{d/\varepsilon} & \check{x}_r < \check{x}_n < \check{x}_g, \check{x}_g < \check{x}_n < \check{x}_r \\ 0 & \text{else} \end{cases} \tag{11}$$

If we sample it for t times, where

$$t = d/\delta \tag{12}$$

Here, δ is approaching to zero in the same order as ε approaching zero. Then, we,

$$\begin{aligned} & P(x_\tau \overset{t}{=} x_n | x_r, x_g) \\ = \; & 1 - (1 - P(\check{x}_\tau \overset{1}{=} \check{x}_n | \check{x}_r, \check{x}_g))^t \\ = \; & \begin{cases} 1 - (1 - \frac{1}{d/\varepsilon})^{d/\delta} & \check{x}_r < \check{x}_n < \check{x}_g, \check{x}_g < \check{x}_n < \check{x}_r \\ 0 & \text{else} \end{cases} \end{aligned}$$

Following consider this limit,

$$\begin{aligned}
&\lim_{\varepsilon,\delta\to 0}(1-\frac{1}{d/\varepsilon})^{d/\delta}\\
=&\lim_{\varepsilon,\delta\to 0}e^{d/\delta\ln(1-\frac{1}{d/\varepsilon})}\\
=&\lim_{\varepsilon,\delta\to 0}e^{\frac{\ln(\frac{d-\varepsilon}{d})}{\delta/d}}\\
=&\lim_{\varepsilon,\delta\to 0}e^{\frac{-1}{\frac{d-\varepsilon}{1/d}}}\\
=&e^{-1}
\end{aligned} \tag{13}$$

which means

$$\begin{aligned}
&P(x_\tau=x_n|x_r,x_g)=\lim_{\varepsilon,\delta\to 0}P(\check{x}_\tau\overset{t}{=}\check{x}_n|\check{x}_r,\check{x}_g)\\
=&\begin{cases}1-e^{-1} & x_r<x_n<x_g, x_g<x_n<x_r\\ 0 & \text{else}\end{cases}
\end{aligned} \tag{14}$$

Now, we propose our update rules for the *Discriminator* D with parameter θ to be optimized,

$$\theta\longrightarrow\theta+\nabla_\theta|\nabla_{x_\tau}D^\theta(x_\tau)-\frac{x_r-x_g}{|x_r-x_g|}|^2 \tag{15}$$

Lets take a look at it at a specific point, i.e., x_n,

$$\begin{aligned}
&\nabla_{x_\tau=x_n}D^\theta(x_\tau=x_n)\\
=&P(x_\tau=x_n|x_g<x_n<x_r)P(x_g<x_n<x_r)\\
&-P(x_\tau=x_n|x_r<x_n<x_g)P(x_r<x_n<x_g)
\end{aligned} \tag{16}$$

Since (14), we know that

$$P(x_\tau=x_n|x_g<x_n<x_r)=1-e^{-1} \tag{17}$$

$$P(x_\tau=x_n|x_r<x_n<x_g)=1-e^{-1} \tag{18}$$

Finally, we have,

$$\begin{aligned}
&\nabla_{x_\tau=x_n}D^\theta(x_\tau=x_n)\\
=&[P(x_g<x_n<x_r)-P(x_r<x_n<x_g)](1-e^{-1})\\
=&[\int_0^{x_n}\mathbb{P}_g(x)dx\int_{x_n}^1\mathbb{P}_r(x)dx)\\
&-\int_0^{x_n}\mathbb{P}_r(x)dx\int_{x_n}^1\mathbb{P}_g(x)dx)](1-e^{-1})\\
=&[\int_{x_n}^1\mathbb{P}_r(x)dx-\int_{x_n}^1\mathbb{P}_g(x)dx](1-e^{-1})
\end{aligned} \tag{19}$$

Now, we can give the update rule of *Generator* G with parameter β to be learnt,

$$\theta\longrightarrow\theta+\nabla_\theta|\nabla_{x_\tau}D^\theta(x_\tau)-\frac{x_r-x_g}{|x_r-x_g|}|^2 \tag{20}$$

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$$\begin{aligned}
\mathbb{P}_{\tau|r,g}&=1-(1-P(x_\tau=x_n|x_r,x_g))^t\\
&=\lim_{\Delta t\to 0}1-(1-\frac{1}{\|x_r-x_g\|}[x_r,x_g])^{\frac{\|x_r-x_g\|}{\Delta t}}
\end{aligned} \tag{21}$$

$$\mathbb{P}_\tau=\mathbb{P}_{\tau|r,g}\mathbb{P}_{r,g} \tag{22}$$

Store

$$H^*(x,\mathbb{P}_r,\mathbb{P}_g)=|\int_x^1\mathbb{P}_r(x')dx'-\int_x^1\mathbb{P}_g(x')dx'| \tag{23}$$

, so that the integral operation in (23) can be conducted in $[0,1]$, instead of $[-\infty,+\infty]$. This distance is modeled for every x, which means we train the generative model g to minimize H^* at every x_g,

$$\min_g\mathbb{E}_{x_g\sim\mathbb{P}_g}[H^*(x_g,\mathbb{P}_r,\mathbb{P}_g)] \tag{24}$$

To give insight on why it is better This distance is better than Wasserstein distance in the sense that it computes the unbalance of the whole distribution at every point.

Assuming we have a optimal D model that can model the part in the

Following Chris's second equation,

$$\mathbb{E}[f(X_r)]-\mathbb{E}[f(X_g)]=\sum_{n=1}^\infty\frac{a_n}{n!}(\mathbb{E}[X_r^n]-\mathbb{E}[X_g^n]) \tag{25}$$

The coefficient in above equation, i.e., $a_0,a_1,...,a_n$ is variables to be learnt, which means it is modeled by a neural network D with parameter vector θ_n and input of X_r or X_g, and it is different for X_r and X_g,

$$a_n=D_{\theta_n}(X_r) \tag{26}$$

$$b_n=D_{\theta_n}(X_g) \tag{27}$$

As we discussed, $\theta_0,\theta_1,...,\theta_n$ may share most of the parameters. So Chris (25) should be,

$$\mathbb{E}[f(X_r)]-\mathbb{E}[f(X_g)]=\sum_{n=1}^\infty(\mathbb{E}[\frac{a_n}{n!}X_r^n]-\mathbb{E}[\frac{b_n}{n!}X_g^n]) \tag{28}$$

or to be more specific,

$$\begin{aligned}
&\mathbb{E}[f(X_r)]-\mathbb{E}[f(X_g)]=\\
&\sum_{n=1}^\infty(\mathbb{E}[\frac{D_{\theta_n}(X_r)}{n!}X_r^n]-\mathbb{E}[\frac{D_{\theta_n}(X_g)}{n!}X_g^n])
\end{aligned} \tag{29}$$

I do not know how to continue to prove it is

Consider,

$$x_r\sim\mathbb{P}_r \tag{30}$$

$$x_g\sim\mathbb{P}_g \tag{31}$$

$$u\sim U[0,1] \tag{32}$$

$$x_u=ux_u+(1-u)x_g \tag{33}$$

where $U[0,1]$ is uniform distribution between 0 and 1. Assuming x_u follows a distribution given by $\mathbb{P}_u$,

$$x_u\sim\mathbb{P}_u \tag{34}$$

Apparently, $\mathbb{P}_u$ can be represented by $\mathbb{P}_r$ and $\mathbb{P}_g$, but in a tricky way.

I think the distance we are trying to minimize for the new loss is,

$$H^*(\mathbb{P}_r,\mathbb{P}_g)=\int_{\not\kappa}^{\not\kappa}\{|\int_x^{\not\kappa}\mathbb{P}_r(x')dx'-\int_x^{\not\kappa}\mathbb{P}_g(x')dx'|\}dx \tag{35}$$

Since we update the model on position x_u, we actually can only achieve,

$$H(\mathbb{P}_r, \mathbb{P}_g) = \mathbb{E}_{x_u \sim \mathbb{P}_u}\{\int_{x_u}^{\not\perp} \mathbb{P}_r(x)dx - \int_{x_u}^{\not\perp} \mathbb{P}_g(x)dx\} \quad (36)$$

and x_g is sampled from $\mathbb{P}_g$,

$$x_g \sim \mathbb{P}_g \quad (37)$$

which is produced by a generative model G^β, with parameter vector β to to be optimized.

Then we build a model D^θ with parameter vector θ. For every set of $\{x_r, x_g, x_\tau\}$, the update rule of θ is,

$$\theta \longrightarrow \theta + \nabla_\theta \|\nabla_{x_\tau} D^\theta(x_\tau) - \frac{x_r - x_g}{\|x_r - x_g\|}\|^2 \quad (38)$$

which means the optimal D^θ has the following attribute,

$$\nabla_x D^{\theta^*}(x) = \mathbb{E}_{x_r \sim \mathbb{P}_r, x_g \sim \mathbb{P}_g}\{\frac{x_r - x_g}{\|x_r - x_g\|}\} \quad (39)$$

Under this D^{θ^*}, the update rule of G^β is

$$\min_\phi \mathbb{E}_{(P_g, P_r, U)}[\|\nabla_{\tilde{x}} f_\phi(x_{\tilde{x}}) - \frac{x_r - x_g}{\|x_r - x_g\|}\|^2] \quad (40)$$

$$\max_g \mathbb{E}_{(P_g, P_r, U)}[f_\phi(x_g)] \quad (41)$$

the same as,

$$\min_\phi \mathbb{E}_{(P_g, P_r, U)}[\|\nabla_{\tilde{x}} f_\phi(x_{\tilde{x}}) - \frac{x_g - x_r}{\|x_g - x_r\|}\|^2] \quad (42)$$

$$\min_g \mathbb{E}_{(P_g, P_r, U)}[f_\phi(x_g)] \quad (43)$$

I believe the distance we are minimizing for the new loss is,

where x_τ is a random variable computed by,

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- The paper size for final submission must be US letter without exception.
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- No document may be password protected.
- Neither the PDFs nor the source may contain any embedded links or bookmarks.
- Your source and PDF must not have any page numbers, footers, or headers.

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In the LaTeX source for your paper, you **must** place the following lines as shown in the example in this subsection. This command set-up is for three authors. Add or subtract author and address lines as necessary, and uncomment the portions that apply to you. In most instances, this is all you need to do to format your paper in the Times font. The helvet package will cause Helvetica to be used for sans serif. These files are part of the PSNFSS2e package, which is freely available from many Internet sites (and is often part of a standard installation).

Leave the setcounter for section number depth commented out and set at 0 unless you want to add section numbers to your paper. If you do add section numbers, you must uncomment this line and change the number to 1 (for section numbers), or 2 (for section and subsection numbers). The style file will not work properly with numbering of subsubsections, so do not use a number higher than 2.

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The Following Must Appear in Your Preamble

```
\documentclass[letterpaper]{article}
\usepackage{aaai}
\usepackage{times}
\usepackage{helvet}
\usepackage{courier}
\usepackage{url}
\usepackage{graphicx}
\frenchspacing
% Add additional packages here. The following
% packages may NOT be used  (this list
% is not exhaustive:
% authblk, caption, CJK, float, fullpage, geometry,
%hyperref, layout, nameref, natbib, savetrees,
%setspace, titlesec, tocbibind, ulem
%
%US Lettersize Paper Is Required
\setlength{pdfpagewidth}{8.5in}
\setlength{pdfpageheight}{11in}\\
%
%
% PDFINFO
% You are required to complete the following
% for pass-through to the PDF.
% No LaTeX commands of any kind may be
% entered. The parentheses and spaces
% are an integral part of the
% pdfinfo script and must not be removed.
%
\pdfinfo{
/Title (Input Your Paper Title Here)
/Author (John Doe, Jane Doe)
/Keywords (Input your keywords in this optional area)
}
%
%Section Numbers
% Uncomment if you want to use section numbers
```

```
% and change the 0 to a 1 or 2
% \setcounter{secnumdepth}{0}

% Title and Author Information Must Immediate Follow
% the pdfinfo within the preamble
%
\title{Title}\\
\author\{Author 1 \ and Author 2\\
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\ And\\
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```
%
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\maketitle
\begin{abstract}
%...
\end{abstract}
```

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```
%References and End of Paper
%These lines must be placed at the end of your paper
\bibliography{Bibliography-File}
\bibliographystyle{aaai}
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```

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...
\bibliography{Bibliography-File}
\bibliographystyle{aaai}
\end{document}
```

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- CJK
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- natbib
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- \input
- \vspace or vskip (when used before or after a section or subsection)
- \addtolength
- \columnsep
- \top margin (or text height or addsidemargin or even side margin)
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- \break
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- \pagebreak

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The default paper size in most installations of LaTeX is A4. However, because we require that your electronic paper be formatted in US letter size, you will need to alter the default for this paper to US letter size. Assuming you are using the 2e version of LaTeX, you can do this by including the [letterpaper] option at the beginning of your file: \documentclass[letterpaper]article.

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If your paper is too long, turn on \frenchspacing, which will reduce the space after periods. Next, shrink the size of your graphics. Use \centering instead of \begin{center} in your figure environment. For mathematical environments, you may reduce fontsize. You may also alter the size of your bibliography by inserting \fontsize{9.5pt}{10.5pt} \selectfont right before the bibliography (the minimum size is \fontsize{9.0pt}{10.0pt}.

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\textsuperscript{1}AffiliationOne}\\
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University Technical Report
Rice, J. 1986. Poligon: A System for Parallel Problem Solving, Technical Report, KSL-86-19, Dept. of Computer Science, Stanford Univ.

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Acknowledgments

AAAI is especially grateful to Peter Patel Schneider for his work in implementing the aaai.sty file, liberally using the ideas of other style hackers, including Barbara Beeton. We also acknowledge with thanks the work of George Ferguson for his guide to using the style and BibTeX files — which has been incorporated into this document — and Hans Guesgen, who provided several timely modifications, as well as the many others who have, from time to time, sent in suggestions on improvements to the AAAI style.

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