A LaTeX Template for Writing Papers

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Abstract

This document provides some useful tips as well as serves as a template for writing a paper in LaTeX. To understand how LaTeX works, you should compare the source code and the output PDF.

Keywords: keyword1; keyword2; keyword3

When you read this PDF file, please also read the .tex file together.
This document contains several custom commands and packages preferred by Dr. Kwon. Graduate students of Dr. Kwon are encouraged to follow his tastes. :)

1 Editor

For macOS users, I recommend TeXShop and BibDesk, which are included in the MacTeX distributions: `https://tug.org/mactex/`. You can install it by `brew install --cask mactex`.

Generally, I also recommend VS Code with the 'LaTeX Workshop' extension by James Yu for editing .tex files and JabRef (a reference management tool) for editing .bib files. These are included in your LaTeX distributions—TeXLive recommended—and are available for all major operation systems: `https://www.tug.org/texlive/`. In Ubuntu, `sudo apt install texlive-full`.

Most LaTeX editors have a built-in PDF viewer. LaTeX users should use forward/backward PDF sync. After compiling your .tex file, do 'Ctrl + Click' or 'Command + Click' on some text part in the .tex file. It will send you to the corresponding part in the output PDF file. While reading your PDF file (in TeXworks), also use 'Ctrl + Click' or 'Command + Click' on some text in the .pdf file. It will again send you to the corresponding part in the source TeX file. Use this functionality to read this document. By the way, the sync will not work for boxed code and text.

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2 Overleaf

Overleaf is an excellent online LaTeX editor for collaboration. However, I prefer using LaTeX locally and collaborate via GitHub.com.

3 Text

```
In LaTeX, just enter an empty line for a new paragraph.

Like this. Some random text: But I must explain to you how all this mistaken
    idea of denouncing pleasure and praising pain was born, and I will give you
    a complete account of the system and expound the actual teachings of the
    great explorer of the truth, the master-builder of human happiness.

The first graph in a new section does not have an indentation.
It is a standard style of writing in English.
The subsequent paragraphs have an indentation.
Line changes in the LaTeX code do not create a new paragraph.
Only an empty line creates a new paragraph.

Some more random text:
To take a trivial example,
which of us ever undertakes laborious physical exercise,
except to obtain some advantage from it?
But who has any right to find fault with a man who chooses to enjoy a pleasure
    that has no annoying consequences
or one who avoids a pain that produces no resultant pleasure?
```

In LaTeX, just enter an empty line for a new paragraph.

Like this. Some random text: But I must explain to you how all this mistaken idea of denouncing pleasure and praising pain was born, and I will give you a complete account of the system and expound the actual teachings of the great explorer of the truth, the master-builder of human happiness.

The first graph in a new section does not have an indentation. It is a standard style of writing in English. The subsequent paragraphs have an indentation. Line changes in the LaTeX code do not create a new paragraph. Only an empty line creates a new paragraph.

Some more random text: To take a trivial example, which of us ever undertakes laborious physical exercise, except to obtain some advantage from it? But who has any right to find fault with a man who chooses to enjoy a pleasure that has no annoying consequences or one who avoids a pain that produces no resultant pleasure?

3.1 Do not use backslashes

```
Don't use double backslashes \verb|\\| for a new paragraph as done in this
    paragraph.
Double backslashes will be used in tables and equations only.
Some random text: But I must explain to you how all this mistaken idea of
    denouncing pleasure and praising pain was born, and I will give you a
    complete account of the system and expound the actual teachings of the great
     explorer of the truth, the master-builder of human happiness. \\
If you use double backslashes for a new paragraph, it will look very bad. Check
     the indentation.
Some more random text: To take a trivial example, which of us ever undertakes
    laborious physical exercise except to obtain some advantage from it? But who
     has any right to find fault with a man who chooses to enjoy a pleasure that
     has no annoying consequences or one who avoids a pain that produces no
    resultant pleasure?\\

If you use double backslashes \emph{and} an empty line for a new paragraph, it
    will give you double empty lines.
Some more random text: To take a trivial example, which of us ever undertakes
    laborious physical exercise except to obtain some advantage from it? But who
     has any right to find fault with a man who chooses to enjoy a pleasure that
     has no annoying consequences or one who avoids a pain that produces no
    resultant pleasure?\\
Please compare this with the text on the previous page.
```

Don't use double backslashes \\ for a new paragraph as done in this paragraph. Double backslashes will be used in tables and equations only. Some random text: But I must explain to you how all this mistaken idea of denouncing pleasure and praising pain was born, and I will give you a complete account of the system and expound the actual teachings of the great explorer of the truth, the master-builder of human happiness.
If you use double backslashes for a new paragraph, it will look very bad. Check the indentation. Some more random text: To take a trivial example, which of us ever undertakes laborious physical exercise except to obtain some advantage from it? But who has any right to find fault with a man who chooses to enjoy a pleasure that has no annoying consequences or one who avoids a pain that produces no resultant pleasure?

If you use double backslashes *and* an empty line for a new paragraph, it will give you double empty lines. Some more random text: To take a trivial example, which of us ever undertakes laborious physical exercise except to obtain some advantage from it? But who has any right to find fault with a man who chooses to enjoy a pleasure that has no annoying consequences or one who avoids a pain that produces no resultant pleasure?
Please compare this with the text on the previous page.

3.2 Emphasizing

If you want to *emphasize* some *words*, use `\emph{...words..}`, instead of `\textit{...words..}`.

3.3 Quotation marks

Quotation marks are input differently in LaTeX.

```
``Hello World''
"Hello World"

`linear problem'
'linear problem'
```

“Hello World” ”Hello World”
‘linear problem’ ’linear problem’

The key for ` is usually located left to the key for number 1.

3.4 Dashes

There are different kinds of ‘-’:

Hyphen is a single ‘-’ in text mode.

```
shortest-path
```

shortest-path

En dash is a double ‘-’ in text mode.

```
1999--2015,
New York--London flight,
constraints \eqref{const2}--\eqref{const5}
```

1999–2015, New York–London flight, constraints (2)–(5)

Em dash is a triple ‘-’ in text mode.

```
Since 2007, the consensus of the economic
    establishment---bankers, policymakers,
    CEOs, stock analysts, pundits---has been
     catastrophically wrong.
```

Since 2007, the consensus of the economic establishment—bankers, policymakers, CEOs, stock analysts, pundits—has been catastrophically wrong.

Minus is a single ‘-’ in math mode.

```
 $-310$, $x-y$
```

-310, $x - y$

Read more at `https://en.wikipedia.org/wiki/Dash`.

4 Citation and Cross-Referencing

You need to provide `.bib` files. Look at the end of this document for something like a ‘bibliography.’ This template uses `sample_ref.bib`. Also, learn how to use BibTeX. (Google it!)

- Textual citation:

```
\citet{Kwon2013rsp}
```

Kwon et al. (2013)

- Parenthetical citation:

`\citep{Kwon2013rsp}`	(Kwon et al., 2013)

- Multiple parenthetical citations:

`\citep{Bertsimas2004,Chaerani2005, Kouvelis1996,gabrel2012recent}`	(Bertsimas and Sim, 2004; Chaerani et al., 2005; Kouvelis and Yu, 1996; Gabrel et al., 2012)

- If you need multiple *textual* citations, it is better to write:

`\citet{Bertsimas2004}, \citet{Chaerani2005}, \citet{Kouvelis1996}, and \citet{gabrel2012recent},`	Bertsimas and Sim (2004), Chaerani et al. (2005), Kouvelis and Yu (1996), and Gabrel et al. (2012),

  instead of

`\citet{Bertsimas2004,Chaerani2005, Kouvelis1996,gabrel2012recent}.`	Bertsimas and Sim (2004); Chaerani et al. (2005); Kouvelis and Yu (1996); Gabrel et al. (2012).

See them in action:

> When the uncertain set is box-constrained, the RSP problem can be solved in polynomial time (Bertsimas and Sim, 2003), while the problem is NP-hard when the uncertain set is an ellipsoid (Bertsimas and Sim, 2004; Chaerani et al., 2005) and a set of scenarios (Kouvelis and Yu, 1996). We refer readers to Ben-Tal et al. (2009) and Gabrel et al. (2012) and references therein for general robust optimization methods.

For cross-referencing, you should *never* do

`Section 1.`	Section 1.

You must always do

`Section \ref{sec:editor}.`	Section 1.

Find where `\label{sec:editor}` is in this `.tex` document.

If you see ?? in your PDF, you would need to compile your LaTeX code one more time (or some errors).

Always use cross-referencing:

`Equation \eqref{const1} or (\ref{const1}).`	Equation (1) or (1).
`Table \ref{tbl:bad_example}.`	Table 2.
`Figure \ref{fig:map}.`	Figure 1.

5 Math

5.1 Inline equations

```
Inline equations can be like $\sum_{j:(i,j)\
    in\Ac} x_{ij}$.
```

Inline equations can be like $\sum_{j:(i,j)\in\mathcal{A}} x_{ij}$.

5.2 Single-line equations

A single-line equation:

```
\begin{equation}
 \sum_{j:(i,j)\in\Ac} x_{ij} = 1 \quad \
     forall i\in\Nc \label{const1}
\end{equation}
```

$$\sum_{j:(i,j)\in\mathcal{A}} x_{ij} = 1 \quad \forall i \in \mathcal{N} \tag{1}$$

I used `\Ac` as a shorthand for `\mathcal{A}` to denote $\mathcal{A}$.

5.3 Notation consistency

```
Try to give some consistency in your notation.
I usually use calligraphic letters to denote sets like set of nodes $\Nc$, set
    of arcs $\Ac$, set of shipments $\Sc$ as in $n\in\Nc$ or $\sum_{s\in\Sc}
    z_s$, and so on.
Lower-case Roman alphabets for variables like $x_{ij}$, $y_i$, and $z_j$,
and boldfaced versions for vectors like $\vec{x}$, $\vec{y}$, and $\vec{z}$.
Boldfaced upper-case Roman alphabets are for matrices for $\mat{A}$ and $\mat{M
    }$.
Upper-case Roman alphabets like $N$, $A$, and $S$ for constants as in $n=1,...,
    N$ or $\sum_{s=1}^S x_s$.
I usually use lower-case Greek letters for dual variables: $\lambda_i$, $\
    rho_j$, etc.
Upper-case Greek letters may be some special sets or sets of dual variables: $\
    Lambda$, $\Theta$, etc.
If you used $a$ for something, then you better use $\vec{a}$, $\mat{A}$, $A$,
    and $\Ac$ for something related to $a$, as much as you can.
```

Try to give some consistency in your notation. I usually use calligraphic letters to denote sets like set of nodes $\mathcal{N}$, set of arcs $\mathcal{A}$, set of shipments $\mathcal{S}$ as in $n \in \mathcal{N}$ or $\sum_{s\in\mathcal{S}} z_s$, and so on. Lower-case Roman alphabets for variables like x_{ij}, y_i, and z_j, and boldfaced versions for vectors like $\mathbf{x}$, $\mathbf{y}$, and $\mathbf{z}$. Boldfaced upper-case Roman alphabets are for matrices for $\mathbf{A}$ and $\mathbf{M}$. Upper-case Roman alphabets like N, A, and S for constants as in $n = 1, ..., N$ or $\sum_{s=1}^{S} x_s$. I usually use lower-case Greek letters for dual variables: λ_i, ρ_j, etc. Upper-case Greek letters may be some special sets or sets of dual variables: Λ, Θ, etc. If you used a for something, then you better use $\mathbf{a}$, $\mathbf{A}$, A, and $\mathcal{A}$ for something related to a, as much as you can.

Read also '`math_notation.pdf`' for more on the mathematical notation: `https://github.com/kaist-comet/LaTeX-Paper-Template/blob/master/math_notation.pdf`.

5.4 Multiple-line equations

Multiple lines:

```
\begin{align}
 a + b & = c \label{const2} \\
 a + b & = c \nonumber \\
 a + b & = c \label{const3} \\
 a + b & = c \label{const4} \\
 a + b & = c \label{const5}
\end{align}
```

$$a + b = c \tag{2}$$
$$a + b = c$$
$$a + b = c \tag{3}$$
$$a + b = c \tag{4}$$
$$a + b = c \tag{5}$$

Note `\nonumber` in the second line and no `\\` in the last line.

5.5 Single-line equations in multiple lines

A single equation that stretches to multiple lines

```
\begin{multline}
 \sum a_i + \sum b_i \\
 + \sum c_i + \sum d_i \\
 + \sum e_i + \sum f_i \\
 + \sum g_i + \sum h_i = 1
\end{multline}
```

$$\sum a_i + \sum b_i + \sum c_i + \sum d_i + \sum e_i + \sum f_i + \sum g_i + \sum h_i = 1 \tag{6}$$

5.6 Cross-referencing

When you want cross-referencing, do this:

```
\eqref{const1}, or \eqref{const2}--\eqref{
    const5}.
```

(1), or (2)–(5).

5.7 Equations without numbering

If you don't want numbering, just add `*`, like:

```
\begin{equation*}
 a + b = c
\end{equation*}
```

$$a + b = c$$

or

```
\[
  a + b = c
\]
```

$$a + b = c$$

or

```
\begin{align*}
 a + b & = c \\
 a + b & = c
\end{align*}
```

$$a + b = c$$
$$a + b = c$$

5.8 Do not use words

Please do not use words for variables.

- Don't:

```
$counter_1 = 3 + 10$
```

$counter_1 = 3 + 10$

where $counter_1$ may be confused with $c \times o \times u \times n \times t \times e \times r_1$.

- Instead do:

```
$c_i = 3 + 10$
```

$c_i = 3 + 10$

or

```
$\text{counter}_1 = 3 + 10$
```

$\text{counter}_1 = 3 + 10$

or

```
$\textsf{counter}_1 = 3 + 10$
```

$\textsf{counter}_1 = 3 + 10$

depending on the context.

5.9 Vectors and Matrices

You can use

```
$\vec{x}$ as a vector of $x_{ij}$.
```

$\vec{x}$ as a vector of x_{ij}.

Some matrices

```
$\mat{A}$ and $\mat{B}$.
```

$\mat{A}$ and $\mat{B}$.

Some vectors are here:

```
\[
 \vec{y} = \begin{bmatrix}
             3 \\
             2 \\
             1
           \end{bmatrix}
\]
```

$$\vec{y} = \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix}$$

```
\[
 \vec{z} = \begin{bmatrix}
             z_1 \\
             z_2 \\
             \vdots \\
             z_n
           \end{bmatrix}
\]
```

$$\vec{z} = \begin{bmatrix} z_1 \\ z_2 \\ \vdots \\ z_n \end{bmatrix}$$

A matrix is here:

```
\[
 \mat{A} = \begin{bmatrix}
            a_{11} & \cdots & a_{22}  \\
            \vdots & \ddots & \vdots  \\
            a_{1n} & \cdots & a_{nn}
           \end{bmatrix}
\]
```

$$\mathbf{A} = \begin{bmatrix} a_{11} & \cdots & a_{22} \\ \vdots & \ddots & \vdots \\ a_{1n} & \cdots & a_{nn} \end{bmatrix}$$

If you like curly brackets:

```
\[
 \mat{A} = \begin{pmatrix}
            a_{11} & \cdots & a_{22}  \\
            \vdots & \ddots & \vdots  \\
            a_{1n} & \cdots & a_{nn}
           \end{pmatrix}
\]
```

$$\mathbf{A} = \begin{pmatrix} a_{11} & \cdots & a_{22} \\ \vdots & \ddots & \vdots \\ a_{1n} & \cdots & a_{nn} \end{pmatrix}$$

5.10 Theorems

You can write a theorem with a proof.

```
\begin{theorem} \label{thm:fundamental}
If one is not drunken, the following is true
    :
\begin{equation}
        1 + 2 = c
\end{equation}
where $c$ is a constant that represents 3.
\end{theorem}
```

Theorem 1. *If one is not drunken, the following is true:*

$$1 + 2 = c \tag{7}$$

where c is a constant that represents 3.

```
\begin{proof}
Obvious.
\end{proof}
```

Proof. Obvious. □

```
\begin{definition}[Convexity]
A convex function is defined ...
\end{definition}
```

Definition 1 (Convexity)**.** *A convex function is defined ...*

```
\begin{lemma}[Kwon's Lemma]
Lemma.............
\end{lemma}
```

Lemma 1 (Kwon's Lemma)**.** *Lemma.....*

```
\begin{proof}
We can prove this lemma by using Theorem \
    ref{thm:fundamental}.
\end{proof}
```

Proof. We can prove this lemma by using Theorem 1. □

6 Tables

When you prepare tables, please just ignore the positioning of tables in the final PDF file. I put the code for Table 1 above this text and the code for Table 3 below this text. Their actual locations in the output PDF file will be determined by LaTeX. Table 2 is a bad presentation of Table 1. Tables 1–3 are small tables. If you have a big table like Table 4, then you can use '`sidewaystable`'. However, it is best to redesign the table and not to use sideways tables. Think one more time to decide if you really need such a big table to make your arguments clear. When you need a table with table-footnotes, use '`threeparttable`' as in Table 5.

Table 1: The table caption is above the table. Text to the left, numbers to the right.

Name	Location	Number	Number
Michael	Chicago	10	3.190
Sara	Montreal	110	123.148
Sandra	LA	1210	3.000
Alexander	San Francisco	8	0.000

Table 2: A bad presentation.

Name	Location	Number	Number
Michael	Chicago	10	3.190
Sara	Montreal	110	123.148
Sandra	LA	1210	3.000
Alexander	San Francisco	8	0.000

Table 3: Arc attributes for the 8-node network, with ρ_a: the population density along arc a and $c_a(v_a) = A_a(1 + 0.15(v_a/l_a)^4)$.

Arc a				
Start	End	A_a	l_a	ρ_a
1	2	6	900	701
1	3	4	1400	11193
2	3	6	700	1701

Table 4: A sideway table.

	LINGO				Modified EDO				2-Step EDO			
Case	Solution Type	Risk	Toll Revenue	Run Time	Risk	Toll Revenue	Run Time	Objective Gap (%)	Risk	Toll Revenue	Run Time	Objective Gap (%)
1	Global	2469.86	0	4 sec	2945.94	703.28	8 sec	47.75	2469.86	1.96	14 sec	0.08

Table 5: Comparison of Various Paths

Description	Path Name	Setting	Path	Worst-Case Cost [b]
Nominal	l_0	$\Gamma = 0$	$\{1, 2, 4, 3, 8, 12, 14, 15\}$	37,016
B-S[a]	l_1	$\Gamma = 1$	$\{1, 4, 3, 8, 12, 14, 15\}$	25,616
	l_2	$\Gamma = 2$	$\{1, 4, 3, 8, 12, 14, 15\}$	25,616
	l_3	$\Gamma = 3$	$\{1, 4, 3, 8, 12, 14, 15\}$	25,616
	l_4	$\Gamma = 4$	$\{1, 4, 3, 7, 12, 15\}$	25,697
	l_5	$\Gamma = 5$	$\{1, 4, 3, 8, 12, 15\}$	27,035
	l_6	$\Gamma = 6$	$\{1, 4, 3, 8, 12, 15\}$	27,035
This Paper	l^*	$\Gamma_u = 2, \Gamma_v = 3$	$\{1, 4, 3, 7, 12, 14, 15\}$	25,314

[a] Bertsimas and Sim (2003)
[b] The worst-case cost measured with the uncertainty set with $\Gamma_u = 2$ and $\Gamma_v = 3$.

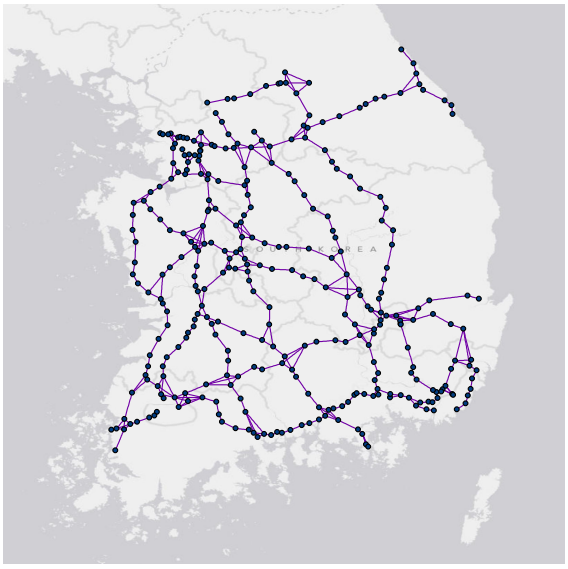


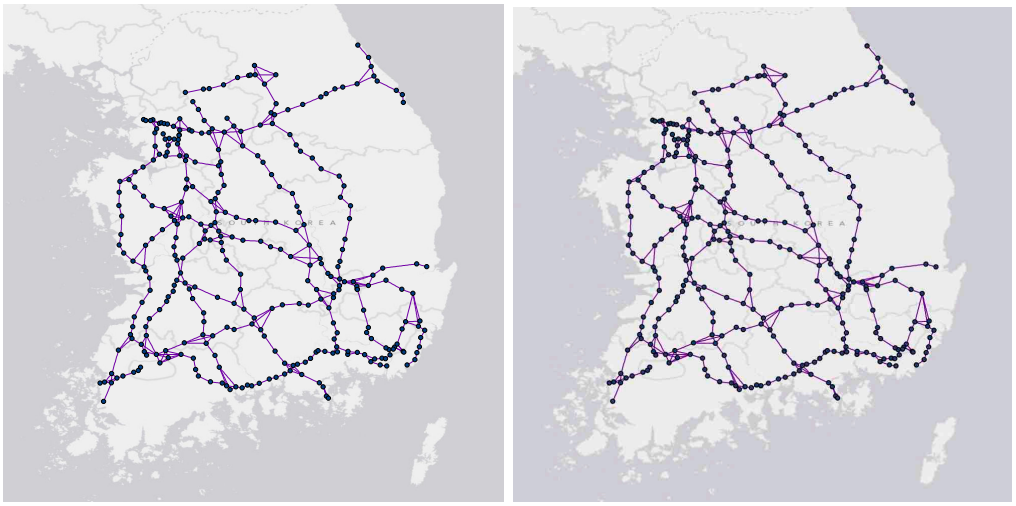
Figure 1: Figure caption is below the figure.

7 Figures

For figures, it is better to put the caption below the figure. See Figure 1. Whenever possible, you should save your figure as a vector-based PDF file. PDF files that were converted from a JPG file do not look good. Compare Figures 2a and 2b. As you have already seen in Figure 2, you can put figures side by side.

If you are using `Python` or `Julia`, you can usually use `savefig(filename.pdf)`.

If you are using `Excel`, read `https://cschleiden.wordpress.com/2009/09/28/howto-export-excel-charts-as-pdf-to-include-in-latex-document/` to learn how to save as PDF.



(a) Vector-based PDF (b) PDF converted from JPG

Figure 2: Figures side by side using `subfigure`. Zoom in and out to see the difference.

8 Concluding Remarks

If you have questions regarding LaTeX, go to `http://tex.stackexchange.com` and ask questions to experts. I go there every day. This document has appendices. Appendix C has some interesting materials.

If you are not sure where to begin, read this: `https://www.ctan.org/tex-archive/info/lshort/?lang=en`.

Acknowledgement

Thank you for reading this. This document was prepared by Changhyun Kwon without any support from any agency.

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References

Ben-Tal, A., L. El Ghaoui, A. Nemirovski. 2009. *Robust optimization*. Princeton University Press.

Bertsimas, D., M. Sim. 2003. Robust discrete optimization and network flows. *Mathematical Programming* **98**(1) 49–71.

Bertsimas, D., M. Sim. 2004. The price of robustness. *Operations Research* **52** 35–53.

Chaerani, D., C. Roos, A. Aman. 2005. The robust shortest path problem by means of robust linear optimization. H. Fleuren, D. Hertog, P. Kort, eds., *Operations Research Proceedings 2004*, *Operations Research Proceedings*, vol. 2004, chap. 42. Springer Berlin Heidelberg, Berlin/Heidelberg, 335–342–342.

Gabrel, V., C. Murat, A. Thiele. 2012. Recent advances in robust optimization and robustness: An overview. Tech. rep., Working paper.

Kouvelis, P., G. Yu. 1996. *Robust Discrete Optimization and Its Applications (Nonconvex Optimization and Its Applications)*. 1st ed. Springer.

Kwon, C., T. Lee, P. Berglund. 2013. Robust shortest path problems with two uncertain multiplicative cost coefficients. URL `http://www.chkwon.net/papers/kwon2013nrl.pdf`. Naval Research Logistics, Accepted.

Appendix

This is an appendix.

A Proofs

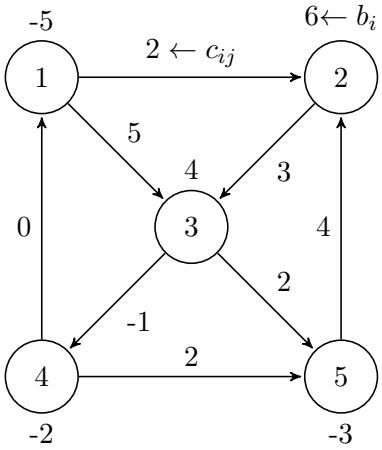
You may want to collect proofs for theorems here. This is Appendix A.

B Data

Or maybe some data. This is Appendix B.

C Drawing

You can also draw some figures within LaTeX. You can put it between text like this:



You can also put them in figures like Figures 3–5. You can also draw a network that is slightly more graphical as in Figure 6. You can even draw a diagram that is as complicated as Figure 7. Visit `http://www.texample.net/tikz/examples/` for more examples and ideas.

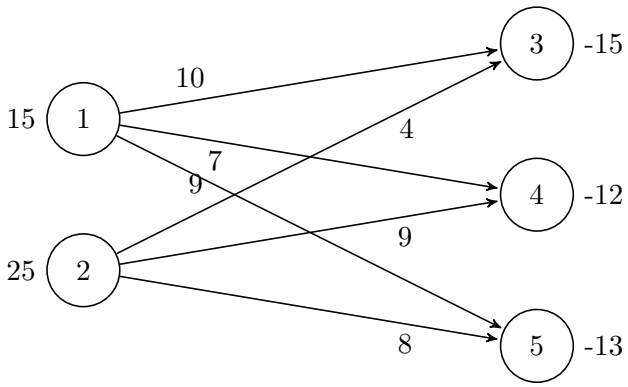


Figure 3: Some network 2

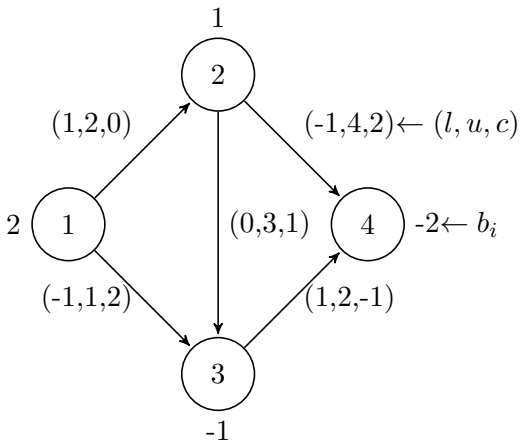
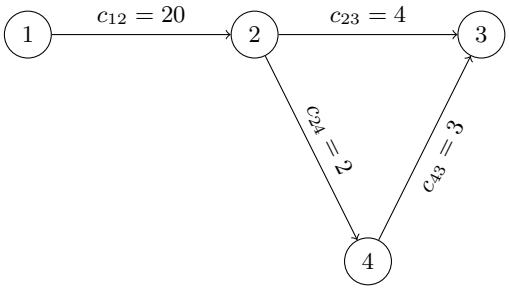


Figure 4: Some network 3



path 1 = $\{1, 2, 3\}$, path length = 24
path 2 = $\{1, 2, 4, 3\}$, path length = 25

Figure 5: Some network 4

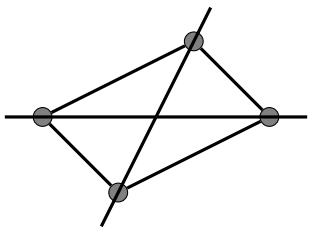


Figure 6: Some network

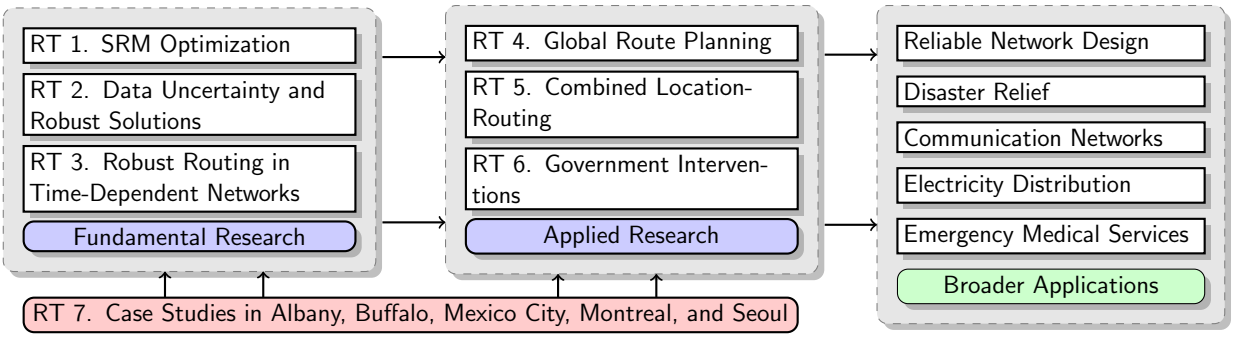
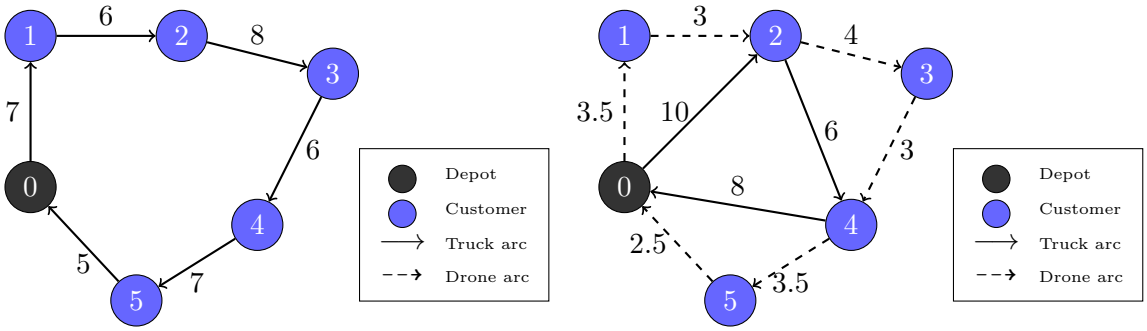


Figure 7: Complicated diagram



(a) The makespan obtained by TSP is 39 (b) The makespan obtained by TSPD is 25

Figure 8: A network with one depot and 5 customers solved by TSP and TSPD.

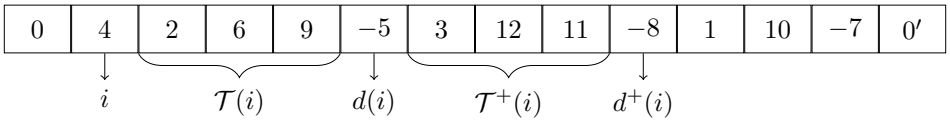
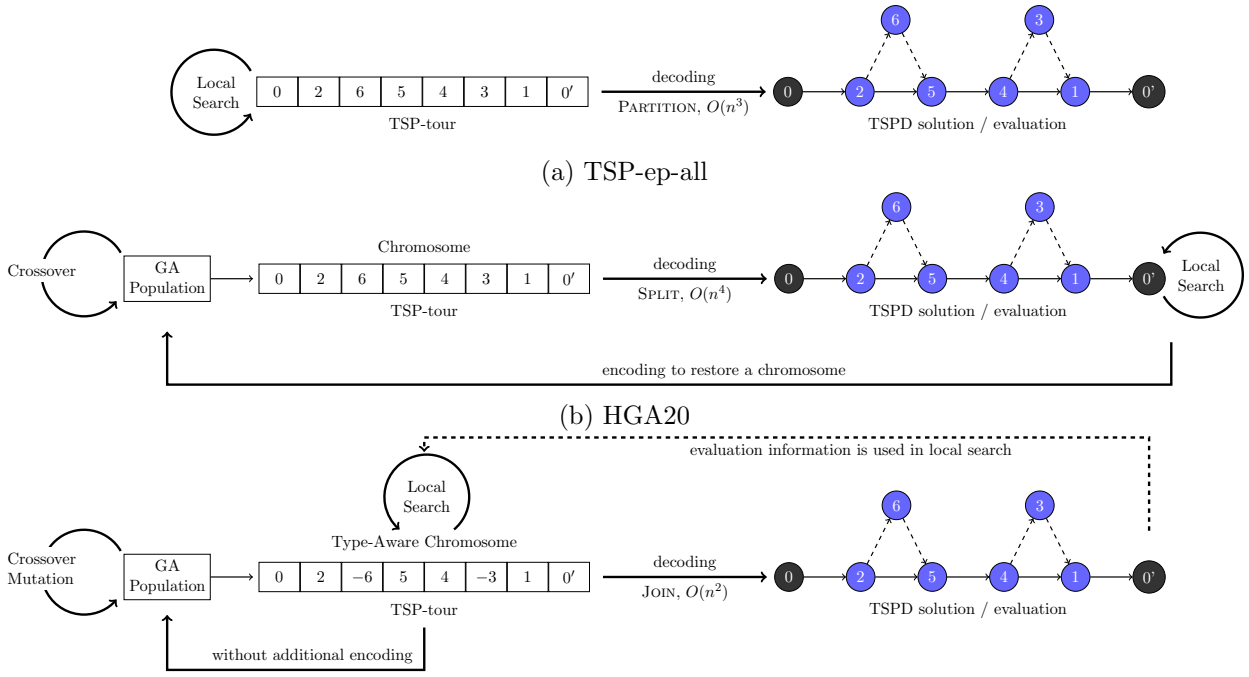


Figure 9: An instance illustrating the notation used in the DP approach

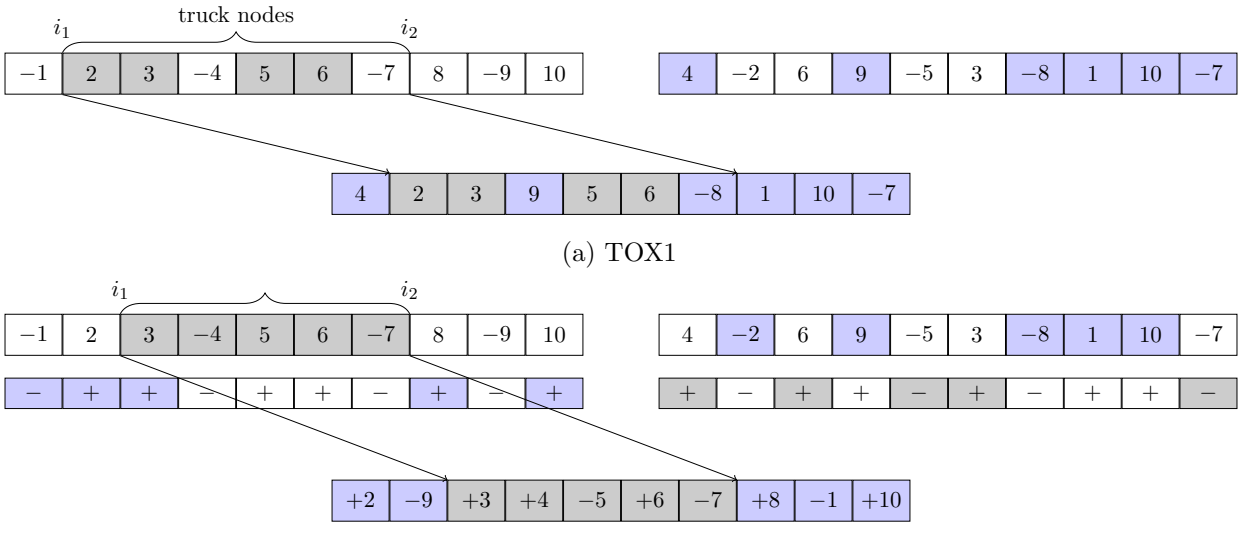


(a) TSP-ep-all

(b) HGA20

(c) HGA-TAC in this paper

Figure 10: Comparing the structure of various approaches



(a) TOX1

(b) TOX2

Figure 11: Examples of the type-aware order crossover operations, TOX1 and TOX2

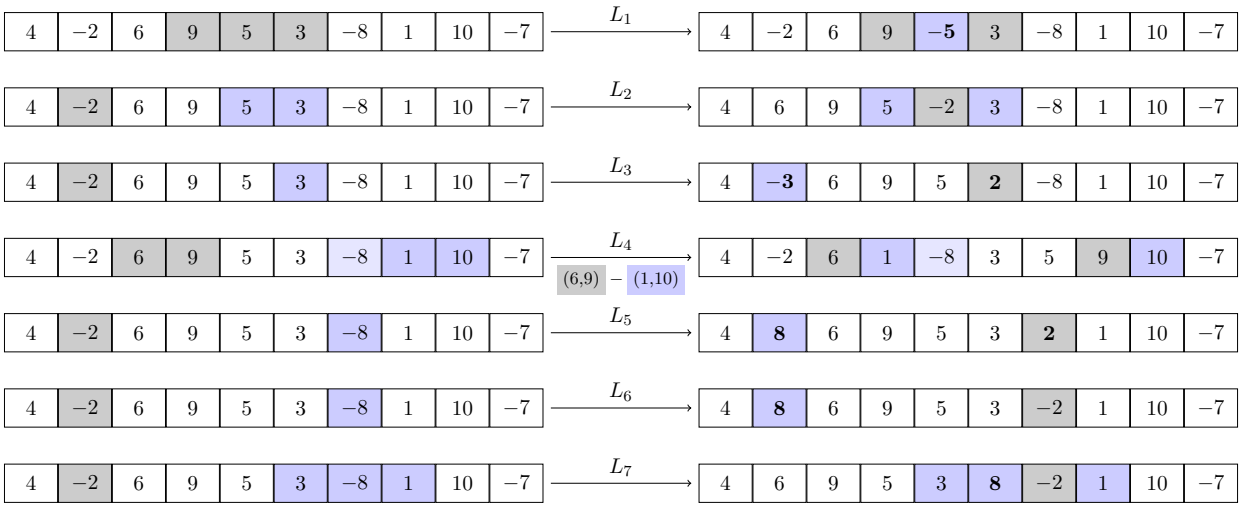


Figure 12: Illustration of L_1 to L_7. The boldface means the type of the node is converted.