

# The Analysis of Static & Real-Time Indoor Position System Data

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A project  
submitted in partial fulfillment of the  
requirements for the degree of

Master of Computer Science & Systems, Cyber Physical Systems

University of Washington Tacoma

2018

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Program Authorized to Offer Degree:  
Institute of Technology

## University of Washington Tacoma

### Abstract

The main objective of this capstone project is to develop a data analysis system that can help dissect Indoor Position System Data by Displaying the results and providing resources to examine and modify the data accordingly. This system is a part of a much larger collaborative project, the other part being the development of an indoor position system which is being developed by Matthew Tolentino and the IPS team, the indoor position system is providing the input for this data analysis system, this input being a set of cartesian coordinate points generated and delivered in either csv or JSON format. The system outputs both a visual and a new dataset that may have modifications added by the user through the system. The position data analysis system parses the input given, to evaluate position and display it into either static two or three-dimensional images, or dynamic real-time images. The user can then use the additional features it provides to apply filters to modify the position values and add new features dataset. The System then returns the data to the also user in either csv or JSON which they can use as desired.

Todd Robbins

Chair of the Supervisory Committee:  
Title of Chair Name of Chairperson  
Department of Chair

This sample dissertation is an aid to students who are attempting to format their theses with L<sup>A</sup>T<sub>E</sub>X, a sophisticated text formatter widely used by mathematicians and scientists everywhere.

- It describes the use of a specialized macro package developed specifically for thesis production at the University. The macros customize L<sup>A</sup>T<sub>E</sub>X for the correct thesis style, allowing the student to concentrate on the substance of his or her text.<sup>1</sup>
  - It demonstrates the solutions to a variety of formatting challenges found in thesis production.
  - It serves as a template for a real dissertation.
-

<sup>1</sup>See Appendix A to obtain the source to this thesis and the class file.

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## GLOSSARY

ARGUMENT: replacement text which customizes a L<sup>A</sup>T<sub>E</sub>X macro for each particular usage.

BACK-UP: a copy of a file to be used when catastrophe strikes the original. People who make no back-ups deserve no sympathy.

CONTROL SEQUENCE: the normal form of a command to L<sup>A</sup>T<sub>E</sub>X.

DELIMITER: something, often a character, that indicates the beginning and ending of an argument. More generally, a delimiter is a field separator.

DOCUMENT CLASS: a file of macros that tailors L<sup>A</sup>T<sub>E</sub>X for a particular document. The macros described by this thesis constitute a document class.

DOCUMENT OPTION: a macro or file of macros that further modifies L<sup>A</sup>T<sub>E</sub>X for a particular document. The option [chapternotes] constitutes a document option.

FIGURE: illustrated material, including graphs, diagrams, drawings and photographs.

FONT: a character set (the alphabet plus digits and special symbols) of a particular size and style. A couple of fonts used in this thesis are twelve point roman and twelve point roman slanted.

FOOTNOTE: a note placed at the bottom of a page, end of a chapter, or end of a thesis that comments on or cites a reference for a designated part of the text.

FORMATTER: (as opposed to a word-processor) arranges printed material according to instructions embedded in the text. A word-processor, on the other hand, is normally controlled by keyboard strokes that move text about on a display.

L<sup>A</sup>T<sub>E</sub>X: simply the ultimate in computerized typesetting.

MACRO: a complex control sequence composed of other control sequences.

PICA: an archaic unit of length. One pica is twelve points and six picas is about an inch.

POINT: a unit of length. 72.27 points equals one inch.

ROMAN: a conventional printing typestyle using serifs. the decorations on the ends of letter strokes. This thesis is set in roman type.

RULE: a straight printed line; e.g., \_\_\_\_\_.

SERIF: the decoration at the ends of letter strokes.

TABLE: information placed in a columnar arrangement.

THESIS: either a master's thesis or a doctoral dissertation. This document also refers to itself as a thesis, although it really is not one.

## ACKNOWLEDGMENTS

I would like to take this time to express my gratitude to The Naval Undersea Warfare Center of Keyport Washington. For both the financial support throughout my Studies and this project, and especially my coworkers for their encouragement. This project would not have been possible without their help and insight.

I want to also thank my parents for being great role models in what hard work and dedication can accomplish. They instilled many life lessons that I carry with me including the rewards of hard work and taking pride in what you do. This has made me successful in and out of the classroom.

Lastly, I would like to thank the University of Washington Tacoma where I have been given the opportunity to work with the exceedingly knowledgeable Faculty and students, who have installed many lessons and skills that will lead me to many future successes.



## Chapter 1

### INTRODUCTION

The need to carefully examine data with an in-depth approach of recording, analyzing, and then presenting those findings in an easily-digestible format is very important especially with data that reflects the real world. According to Wei-Ya Hu (2013), “With the explosion of information, processing massive data and providing accurate information become critical” (p. 1). As Such, the goal for this project was to develop a Position Data Analysis Tool that reads dynamic ultra-wide band Indoor Positioning System data displays the results accurately to help improve the accuracy of these tools.

#### 1.1 The Purpose of This Sample Thesis

This sample is both a demonstration of the quality and propriety of a L<sup>A</sup>T<sub>E</sub>Xformatted thesis and documentation for its preparation. It has made extensive use of a custom class le developed speci cally for this purpose at the University of Washington. Chapter II discusses T<sub>E</sub>X and L<sup>A</sup>T<sub>E</sub>X. Chapter III describes the additional macros and functions provided by the custom thesis class le. Finally, Chapter IV hopes to tie things up.

It is impossible to predict all the formatting problems one will encounter and there will be problems that are best handled by a specialist. The Graduate School may be able to help you nd help. Some departments may also be able to provide L<sup>A</sup>T<sub>E</sub>X assistance.

#### 1.2 Conventions and Notations

In this thesis the typist refers to the user of L<sup>A</sup>T<sub>E</sub>X|the one who makes formatting decisions and chooses the appropriate formatting commands. He or she will most often be the degree candidate.

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<sup>1</sup>See, for example, W. Shakespeare[8] for a recent discussion.

This document deals with L<sup>A</sup>T<sub>E</sub>X typesetting commands and their functions. Wherever possible the conventions used to display text entered by the typist and the resulting formatted output are the same as those used by the T<sub>E</sub>Xbooks. Therefore, typewriter type is used to indicate text as typed by the computer or entered by the typist. It is quite the opposite of italics, which indicates a category rather than exact text. For example, alpha and beta might each be an example of a label.

### 1.3 Nota bene

This sample thesis was produced by the L<sup>A</sup>T<sub>E</sub>X document class it describes and its format is consonant with the Graduate School's electronic dissertation guidelines, as of November, 2014, at least. However, use of this package does not guarantee acceptability of a particular thesis.

## Chapter 2

### A BRIEF DESCRIPTION OF T<sub>E</sub>X

The T<sub>E</sub>X formatting program is the creation of Donald Knuth of Stanford University. It has been implemented on nearly every general purpose computer and produces exactly the same copy on all machines.

#### 2.1 What is it; why is it spelled that way; and what do really long section titles look like in the text and in the Table of Contents?

T<sub>E</sub>X is a formatter. A document's format is controlled by commands embedded in the text. L<sup>A</sup>T<sub>E</sub>X is a special version of T<sub>E</sub>X|preloaded with a voluminous set of macros that simplify most formatting tasks.

T<sub>E</sub>X uses control sequences to control the formatting of a document. These control sequences are usually words or groups of letters prefaced with the backslash character (\). For example, Figure 2.1 shows the text that printed the beginning of this chapter. Note the control sequence \chapter that instructed T<sub>E</sub>X to start a new chapter, print the title, and make an entry in the table of contents. It is an example of a macro defined by the L<sup>A</sup>T<sub>E</sub>X macro package. The control sequence \TeX, which prints the word T<sub>E</sub>X, is a standard macro from the T<sub>E</sub>Xbook. The short control sequence \\ in the title instructed T<sub>E</sub>X to break the title line at that point. This capability is an example of an extension to L<sup>A</sup>T<sub>E</sub>X provided by the uwthesis document class.

Most of the time T<sub>E</sub>X is simply building paragraphs from text in your source files. No control sequences are involved. New paragraphs are indicated by a blank line in the input file. Hyphenation is performed automatically.

`\chapter{A Brief\Description of \TeX}`

The `\TeX` formatting program is the creation of Donald Knuth of Stanford University.

Figure 2.1: The beginning of the Chapter II text

## 2.2 `TEX`books

The primary reference for  $\text{L}^{\text{A}}\text{TEX}$  is Lamport's second edition of the  $\text{L}^{\text{A}}\text{TEX}$  User's Guide[7]. It is easily read and should be sufficient for thesis formatting. See also the  $\text{L}^{\text{A}}\text{TEX}$  Companion[2] for descriptions of many add-on macro packages.

Although unnecessary for thesis writers, the `TEX`book is the primary reference for `TEX`sperts worldwide.

## 2.3 Mathematics

The thesis class does not expand on `TEX`'s or  $\text{L}^{\text{A}}\text{TEX}$ 's comprehensive treatment of mathematical equation printing.<sup>1</sup> The `TEX`book[3],  $\text{L}^{\text{A}}\text{TEX}$  User's Guide[7], and The  $\text{L}^{\text{A}}\text{TEX}$  Companion[2] thoroughly cover this topic.

## 2.4 Languages other than English

Most  $\text{L}^{\text{A}}\text{TEX}$  implementations at the University are tailored for the English language. However,  $\text{L}^{\text{A}}\text{TEX}$  will format many other languages. Unfortunately, this author has never been

---

<sup>1</sup>Although many `TEX`-formatted documents contain no mathematics except the page numbers, it seems appropriate that this paper, which is in some sense about `TEX`, ought to demonstrate an equation or two. Here then, is a statement of the Nonsense Theorem.

Assume a universe  $E$  and a symmetric function  $d$  defined on  $E$ , such that for each  $y \in E$  there exists a  $y^y$ , where  $y^y = y^y$ . For each element  $i$  of  $E$  define  $S(i) = \prod_i y^y + y^y + 0$ . Then if  $RR$  is that subset of  $E$  where  $1 + 1 = 3$ , for each  $i$

$$\lim_{i \rightarrow \infty} d_i = 0; \quad \text{if } i \notin RR;$$

successful in learning more than a smattering of anything other than English. Consult your department or the Tex Users Group.

<http://tug.org/>,

for assistance with non-English formatting.

Unusual characters can be defined via the font maker METAFONT (documented by Knuth[6]). The definitions are not trivial. Students who attempt to print a thesis with custom fonts may soon proclaim,

\ o ' ^ !."

## Chapter 3

### THE THESIS UNFORMATTED

This chapter describes the `uwthesis` class (`uwthesis.cls`, version dated 2014/11/13) in detail and shows how it was used to format the thesis. A working knowledge of Lamport's L<sup>A</sup>T<sub>E</sub>X manual[7] is assumed.

#### 3.1 The Control File

The source to this sample thesis is a single `le` only because ease of distribution was a concern. You should not do this. Your task will be much easier if you break your thesis into several `les`: a `le` for the preliminary pages, a `le` for each chapter, one for the glossary, and one for each appendix. Then use a control `le` to tie them all together. This way you can edit and format parts of your thesis much more efficiently.

Figure 3.1 shows a control `le` that might have produced this thesis. It sets the document style, with options and parameters, and formats the various parts of the thesis|but contains no text of its own.

The `\rst` section, from the `\documentclass` to the `\begin{document}`, defines the document class and options. This sample thesis specifies the `proquest` style, which is now required by the Graduate School and is the default. Two other, now dated, other styles are available: `twoside`, which is similar but produces a wider binding margin and is more suitable for paper printing; and `oneside`, which is really old fashioned. This sample also specified a font size of 11 points. Possible font size options are: 10pt, 11pt, and 12pt. Default is 12 points, which is the preference of the Graduate School. If you choose a smaller size be sure to check with the Graduate School for acceptability. The smaller fonts can produce very small sub and superscripts.

```

% LaTeX thesis control file

\documentclass [11pt, proquest]{uwthesis}[2014/11/13]

\begin{document}

% preliminary pages
%
\prelimpages
\include{prelim}

% text pages
%
\textpages
\include{chap1}
\include{chap2}
\include{chap3}
\include{chap4}

% bibliography
%
\bibliographystyle{plain}
\bibliography{thesis}

% appendices
%
\appendix
\include{appxa}
\include{appxb}

\include{vita}
\end{document}

```

Figure 3.1: A thesis control file (thesis.tex). This file is the input to L<sup>A</sup>T<sub>E</sub>X that will produce a thesis. It contains no text, only commands which direct the formatting of the thesis.



Include most additional formatting packages with `\usepackage`, as describe by Lamport[7]. The one exception to this rule is the `natbib` package. Include it with the `natbib` document option.

Use the `\includeonly` command to format only a part of your thesis. See Lamport[7, sec. 4.4] for usage and limitations.

## 3.2 The Text Pages

A chapter is a major division of the thesis. Each chapter begins on a new page and has a Table of Contents entry.

### 3.2.1 Chapters, Sections, Subsections, and Appendices

Within the chapter title use a `\\` control sequence to separate lines in the printed title (recall Figure 2.1.). The `\\` does not affect the Table of Contents entry.

Format appendices just like chapters. The control sequence `\appendix` instructs L<sup>A</sup>T<sub>E</sub>X to begin using the term ‘Appendix’ rather than ‘Chapter’.

Specify sections and subsections of a chapter with `\section` and `\subsection`, respectively. In this thesis chapter and section titles are written to the table of contents. Consult Lamport[7, pg. 176] to see which subdivisions of the thesis can be written to the table of contents. The `\\` control sequence is not permitted in section and subsection titles.

### 3.2.2 Footnotes

Footnotes format as described in the L<sup>A</sup>T<sub>E</sub>X book. You can also ask for end-of-chapter or end-of-thesis notes. The thesis class will automatically set these up if you ask for the document class option `chapternotes` or `endnotes`.

If selected, `chapternotes` will print automatically. If you choose `endnotes` however you must explicitly indicate when to print the notes with the command `\printendnotes`. See the style guide for suitable endnote placement.

### 3.2.3 Figures and Tables

Standard L<sup>A</sup>T<sub>E</sub>X figures and tables, see Lamport[7, sec. C.9], normally provide the most convenient means to position the figure. Full page floats and facing captions are exceptions to this rule.

If you want a figure or table to occupy a full page enclose the contents in a `fullpage` environment. See figure 3.2.

#### Facing pages

Facing page captions are an artifact of traditional, dead-tree printing, where a left-side (even) page faces a right-side (odd) page.

In the twoside style, a facing caption is full page caption for a full page figure or table and should face the illustration to which it refers. You must explicitly format both pages. The caption part appears on an even page (left side) and the figure or table comes on the following odd page (right side). Enclose the float contents for the caption in a `leftfullpage` environment, and enclose the float contents for the figure or table in a `fullpage` environment. The first page (left side) contains the caption. The second page (right side) could be left blank. A picture or graph might be pasted onto this space. See figure 3.2.

You can use these commands with the `proquest` style, but they have little effect on online viewing.

### 3.2.4 Horizontal Figures and Tables

Figures and tables may be formatted horizontally (a.k.a. landscape) as long as their captions appear horizontal also. L<sup>A</sup>T<sub>E</sub>X will format landscape material for you.

Include the rotating package

```
\usepackage[figuresright]{rotating}
```

and read the documentation that comes with the package.

Figure 3.3 is an example of how a landscape table might be formatted.

```

\begin{figure}[p]% the left side caption
  \begin{leftfullpage}
    \caption{ . . . }
  \end{leftfullpage}
\end{figure}
\begin{figure}[p]% the right side space
  \begin{fullpage}
    . . .
    ( note.. no caption here )
  \end{fullpage}
\end{figure}

```

Figure 3.2: This text would create a double page gure in the two-side styles.

```

\begin{sidewaystable}
...
  \caption{ . . . }
\end{sidewaystable}

```

Figure 3.3: This text would create a landscape table with caption.

### 3.2.5 Figure and Table Captions

Most captions are formatted with the `\caption` macro as described by Lamport[7, sec. C.9]. The `uwthesis` class extends this macro to allow continued gures and tables, and to provide multiple gures and tables with the same number, e.g., 3.1a, 3.1b, etc.

To format the caption for the rst part of a gure or table that cannot t onto a single page use the standard form:

```
\caption[toc ]{text }
```

To format the caption for the subsequent parts of the gure or table use this caption:

```
\caption(-){(continued)}
```

It will keep the same number and the text of the caption will be (continued).

To format the caption for the first part of a multi-part figure or table use the format:

```
\caption(a)[toc ]{text }
```

The figure or table will be lettered (with `a') as well as numbered. To format the caption for the subsequent parts of the multi-part figure or table use the format:

```
\caption(x ){text }
```

where x is b, c, . . . . The parts will be lettered (with `b', `c', . . . ).

### 3.2.6 Line spacing

Normally line spacing will come out like it should. However, the ProQuest style allows single spacing in certain situations: figure content, some lists, and etc. Use `\uwsinglespace` to switch to single spacing within a `\begin{}` and `\end{}` block. The code examples in this document does this.

## 3.3 The Preliminary Pages

These are easy to format only because they are relatively invariant among theses. Therefore the difficulties have already been encountered and overcome by L<sup>A</sup>T<sub>E</sub>X and the thesis document classes.

Start with the definitions that describe your thesis. This sample thesis was printed with the parameters:

```
\Title{The Suitability of the \LaTeX\ Text Formatter\\ for Thesis
      Preparation by Technical and\\ Non-technical Degree
      Candidates}
\Author{Jim Fox}
\Program{IT Infrastructure}
\Year{2012}
```

\Chair{Name of Chairperson}{title}{Chair's department}  
 \Signature{First committee member} \Signature{Next  
 committee member} \Signature{etc}

Use two or more \Chair lines if you have co-chairs.

### 3.3.1 Copyright page

Print the copyright page with \copyrightpage.

### 3.3.2 Title page

Print the title page with \titlepage. The title page of this thesis was printed with

\titlepage

You may change default text on the title page with these macros. You will have to redefine \Degreetext, for instance, if you're writing a Master's thesis instead of a dissertation.<sup>1</sup>

\Degree{degree name} defaults to \Doctor of Philosophy"

\School{school name} defaults to \University of Washington"

\Degreetext{degree text} defaults to \A dissertation submitted . . . "

\textofCommittee{committee label} defaults to \Reading Committee:"

\textofChair{chair label} defaults to \Chair of the Supervisory Committee:"

These definitions must appear before the \titlepage command.

---

<sup>1</sup>If you use these they can be included with the other information before \copyrightpage".

### 3.3.3 Abstract

Print the abstract with `\abstract`. It has one argument, which is the text of the abstract. All the names have already been defined. The abstract of this thesis was printed with

```
\abstract{This sample . . . `real' dissertation.}
```

### 3.3.4 Tables of contents

Use the standard L<sup>A</sup>T<sub>E</sub>X commands to format these items.

### 3.3.5 Acknowledgments

Use the `\acknowledgments` macro to format the acknowledgments page. It has one argument, which is the text of the acknowledgment. The acknowledgments of this thesis was printed with

```
\acknowledgments{The author wishes . . . {\it il miglior fabbro}.\par}}
```

### 3.3.6 Dedication

Use the `\dedication` macro to format the dedication page. It has one argument, which is the text of the dedication.

### 3.3.7 Vita

Use the `\vita` macro to format the curriculum vitae. It has one argument, which chronicles your life's accomplishments.

Note that the Vita is not really a preliminary page. It appears at the end of your thesis, just after the appendices.

## Chapter 4

### RUNNING L<sup>A</sup>T<sub>E</sub>X (AND PRINTING IF YOU MUST)

From a given source T<sub>E</sub>X will produce exactly the same document on all computers and, if needed, on all printers. Exactly the same means that the various spacings, line and page breaks, and even hyphenations will occur at the same places.

How you edit your text les and run L<sup>A</sup>T<sub>E</sub>X varies from system to system and depends on your personal preference.

#### 4.1 Running

The author is woefully out of his depth where T<sub>E</sub>X on Windows is concerned. Google would be his resource. On a linux system he types

```
$ pdflatex uwthesis
```

and it generally works.

#### 4.2 Printing

All implementations of T<sub>E</sub>X provide the option of pdf output, which is all the Graduate School requires. Even if you intend to print a copy of your thesis create a pdf. It will print most anywhere.

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## Appendix A

### WHERE TO FIND THE FILES

The uwthesis class file, uwthesis.cls, contains the parameter settings, macro definitions, and other T<sub>E</sub>Xnical commands which allow L<sup>A</sup>T<sub>E</sub>X to format a thesis. The source to the document you are reading, uwthesis.tex, contains many formatting examples which you may find useful. The bibliography database, uwthesis.bib, contains instructions to BibT<sub>E</sub>X to create and format the bibliography. You can find the latest of these files on:

My page. <http://staff.washington.edu/fox/tex/uwthesis.html>

#### CTAN

<http://tug.ctan.org/tex-archive/macros/latex/contrib/uwthesis/>

(not always as up-to-date as my site)

## VITA

Jim Fox is a Software Engineer with IT Infrastructure Division at the University of Washington. His duties do not include maintaining this package. That is rather an avocation which he enjoys as time and circumstance allow. He welcomes your comments to [fox@uw.edu](mailto:fox@uw.edu).