
Space-Time Block Coding over Rician Fading Channels

FirstName Surname

A thesis submitted in fulfilment of the requirement for the
degree of

Doctor of Philosophy in Engineering
(ELECTRONIC ENGINEERING)



School of Engineering
University of KwaZulu-Natal,
Durban, South Africa

May, 2019

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Co-Supervisor: Dr. FirstName Surname

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May, 2019

As the candidate's supervisor, I have approved this thesis for submission.

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2. This thesis has not been submitted for any degree or examination at any other university.
3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
4. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
 - (a) Their words have been re-written but the general information attributed to them has been referenced,
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Declaration 2 - Publication

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Dedication

This work is dedicated to the users of this template for their contributions to knowledge.

Acknowledgements

The author would like to acknowledge contributions of the following people towards the success of this template: Korede Oluyide, Thabelang Sefanko, Louis Mothwa, Shaheen Solwa, Alaa Aldein Mohamed Ibrahim and Divina Govender.

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Finally, the author would like to thank IEEE Eta Kappa Nu (Mu Eta Chapter), Prof. Jules Raymond Tapamo and Dr Leigh Jarvis - academic leader of discipline of Electrical, Electronic and Computer Engineering, University of KwaZulu-Natal, Durban, South Africa.

Abstract

This template has been designed for postgraduate thesis writing by publication format only in the discipline of Electrical, Electronic and Computer Engineering, School of Engineering, University of KwaZulu-Natal, South Africa.

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List of Acronyms

1G	First Generation Communication Systems
2G	Second Generation Communication Systems
3G	Third Generation Communication Systems
4G	Fourth Generation Communication Systems
5G	Fifth Generation Communication Systems
6G	Sixth Generation Communication Systems
ADSL	Asymmetric Digital Subscriber Line
BPSK	Binary Phase Shift Keying
CR	Constellation Rearrangement
DVB-C	Digital Video Broadcasting Cable

Preface

The research discussed in this dissertation is carried out in the College of Agriculture, Engineering and Science of the University of Kwa-Zulu Natal, Durban, from January 2016 until May 2019 by FirstName Surname under the supervision of Professor FirstName Surname and co-supervised by Dr. FirstName Surname.

As the candidate's supervisor, I, FirstName Surname, agree agree to the submission of this dissertation.

Signed:..... Date:.....

As the candidate's co-supervisor, I, FirstName Surname, agree to the submission of this dissertation.

Signed:..... Date:.....

I, FirstName Surname, hereby declare that all the material incorporated in this dissertation are my own original work, except where acknowledgement is made by name or in the form of a reference. The work contained in herein has not been submitted in any form for any degree or diploma to any other institution.

Signed:..... Date:.....

University of KwaZulu-Natal, December 11, 2019

Part I

Introduction

1 Introduction

What is LATEX? It's the magic software that allows for putting ideas into beautiful amazing texts..... using the magic. The benefits of Latex are that you will never get tired and sick of writing and opening your eyes widely, a key symptom of sickness in word documents. This document is a Microsoft Word template and can be downloaded from the conference website. Information about final paper submission is available on the conference website.

We need to stress the need to have all files in the same folder to avoid file path conflicts and errors! Discuss how important it is to have the .bib file with all references ready as you prepared the Latex file. Always don't copy and paste references since unknown symbols and letters may result to compilation errors.

Remember every document has sections and subsections just like this final document. We shall create these same sections and subsections in Latex. The Latex template is ready but empty. We shall be populating the template with these same texts. Examples of journal articles in citation [1] [2]. Examples of conference proceedings in citation [3] [4] [5].

References

- [1] D. Ayanda, H. Xu, and N. Pillay, “Uncoded M-ary Quadrature Amplitude Modulation Space-time Labeling Diversity with Three Transmit Antennas,” *International Journal of Communication Systems*, vol. 31, no. 18, e3818, Dec. 2018.
- [2] A. D. Mafuta, T. Walingo, and F. Takawira, “Interference Management in LTE-Advanced Cooperative Relay Networks: Decentralized Transceiver Design With Channel Estimation,” *IEEE Access*, vol. 7, pp. 131 078–131 093, Aug. 2019.
- [3] A. D. Mafuta and T. Walingo, “Interference Alignment for Transceiver Design in Multi-User MIMO Relay System,” in *2018 IEEE 88th Vehicular Technology Conference (VTC-Fall)*. IEEE, 2018, pp. 1–5.
- [4] L. Mothwa, J.-R. Tapamo, and T. Mapati, “Conceptual Model of the Smart Attendance Monitoring System Using Computer Vision,” in *2018 14th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)*. IEEE, 2018, pp. 229–234.
- [5] D. Ayanda and H. Xu, “A Unified Error Analysis of Uncoded Space-Time Labeling Diversity with Three Transmit Antennas in Rician Fading Channels,” in *2019 IEEE 2nd Wireless Africa Conference (WAC)*. IEEE, 2019, pp. 1–5.

Part II

Included Chapters

Paper A

Literature Review

1 Abstract

Uncoded space-time labeling diversity (USTLD) is a recent scheme that improves the error performance of space-time block-coded wireless communication links.

2 Introduction

Space-time coded modulation (STCM) is a recent scheme widely employed in wireless communication systems as a result of improvements in reliability and spectral efficiency of multiple-input multiple-output (MIMO) techniques [1].

The remainder of this paper is structured as follows: Section 2 describes the system model of STC. The theoretical expression for error performance is presented in Section 3. Section 4 discusses numerical results. The final conclusion is discussed in Section 5.

3 System Model

This section presents the system model of $2 \times N_R$ MIMO scheme.

3.1 Existing USTLD system model

The conventional MIMO technique. Here's a citation [2].

References

- [1] K. Govindasamy, H. Xu, and N. Pillay, "Space-time block coded spatial modulation with labeling diversity," *International Journal of Communication Systems*, vol. 31, no. 1, p. e3395, Jan. 2018.
- [2] D. A. Chowdhry, A. Hussain, M. Z. U. Rehman, F. Ahmad, A. Ahmad, and M. Pervaiz, "Smart security system for sensitive area using face recognition," in *IEEE Conference on Sustainable Utilization and Development in Engineering and Technology*, 2013, pp. 11–14.

Part I

Included Chapters

Paper B

Methodology

1 Introduction

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed. Simply type your text into this template to comply with the conference paper formatting requirements.

1.1 Simple Equation

Microsoft Word struggles to display mathematical expressions. Especially, expression numbering is usually done manually. Mathematical expressions are centered within a column. For very large equations, the expression may span both columns, but must then be positioned at the top or bottom of a page. All mathematical expressions must be numbered within round brackets, in line with the expression and right-justified. Use B.1 as the labelling convention to reference the following example expression B.1:

$$(x + a)^n = \int_{k=0}^n \binom{n}{k} x^k a^{n-k} \quad (\text{B.1})$$

1.2 Array Equation

You can use the following commends to write the array equations
`\begin{cases} \dots \end{cases}`

$$f(x) = \begin{cases} x^2 & : x < 0 \\ x^3 & : x \geq 0 \end{cases}$$

$$u(x) = \begin{cases} \exp x & \text{if } x \geq 0 \\ 1 & \text{if } x < 0 \end{cases} \quad (\text{B.2})$$

1.3 Other Equations

$$\cos(2\theta) = \cos^2 \theta - \sin^2 \theta \quad (\text{B.3})$$

For the binomial expression, use `\binom{\dots}{\dots}`

$$\frac{n!}{k!(n-k)!} = \binom{n}{k} \quad (\text{B.4})$$

$$\sum_{\substack{0 < i < m \\ 0 < j < n}} P(i, j) \quad (\text{B.5})$$

How to write a matrix in latex? You can use this command
`\begin{pmatrix}... \end{pmatrix}`

$$P = \begin{pmatrix} p_{11} & p_{12} & \dots & p_{1n} \\ p_{21} & p_{22} & \dots & p_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{m1} & p_{m2} & \dots & p_{mn} \end{pmatrix} \quad (\text{B.6})$$

For the adapted bracket size, you can use these commands "`\left(` and `\right)`" or "`\Biggl(` and `\Biggr)`"

$$f\left(\sum_{k=1}^n b_k\right) = f\left(\sum_{k=1}^n b_k\right) \quad (\text{B.7})$$

$$a = \log\left(\sum_{k=1}^n \frac{e^{1+\frac{b_k^2}{c_k^2}}}{1+\frac{b_k^2}{c_k^2}} + 1 + \sum_{k=1}^n \frac{e^{1+\frac{b_k^2}{c_k^2}}}{1+\frac{b_k^2}{c_k^2}}\right) \quad (\text{B.8})$$

2 Conclusion

The algorithms used in this research are the standard algorithms used to build the face recognition model. Despite the simplicity, they are significantly the most used algorithm to experiment the performance of the face recognition systems. There are many other complex and accurate algorithms such as the Artificial Neural Network (ANN) [1], that can be applied.

References

- [1] R. Szeliski, *Computer vision: algorithms and applications*. Springer Science & Business Media, 2010.

Part I

Included Chapters

Paper C

System Model

1 Introduction

At times you may have the need to put your statements or key points in either unnumbered or numbered bulletin format. In latex, this required either an `itemize` or `enumerate` function environments.

To write statements in bulletin format without numbering, we use `itemize` function to realize points as listed below:

1.1 Unordered List

- example of a book in [1]
- example of a book in a series in [2]
- example of a journal article in [3]

1.2 Ordered List

What if you are interested to number your points like shown below? Here we the `enumerate` environment is used to produce numbered points as:

1. example of a conference paper in [4]
2. example of a patent in [5]
3. example of a website in [6]

1.3 Nested List

1. example of a web page in [7]
 - (a) example of a manual in [8]
 - (b) example of a datasheet in [9]
2. example of a master's thesis in [10]
3. example of a technical report in [11]

1.4 Changing the numbering / bullets of List

- Dash
- Dash
- * Asterisk

Here's another citation [12]

2 Conclusion

References

- [1] S. M. Metev and V. P. Veiko, *Laser Assisted Microtechnology*, 2nd ed., R. M. O. Jr., Ed. Berlin Germany: Springer-Verlag, 1998.
- [2] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin Germany: Springer, 1989, vol. 61.
- [3] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," in *IEEE Electron Device Lett.*, vol. 20, Nov 1999, pp. 569—571.
- [4] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in *Proc. ECOC'00*, 2000, p. 109, paper 11.3.4.
- [5] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16 1997.
- [6] (2002) The IEEE website, [Online]. Available: <http://www.ieee.org/>.
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- [9] "PDCA12-70 data sheet," Opto Speed SA, Mezzovico, Switzerland.
- [10] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.
- [11] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of tcp reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.
- [12] L. An, M. Kafai, and B. Bhanu, "Face recognition in multi-camera surveillance videos using dynamic bayesian network," in *Distributed Smart Cameras (ICDSC), 2012 Sixth International Conference on*. IEEE, 2012, pp. 1–6.

Part I

Included Chapters

Paper D

Experimental Results

Abstract

1 Introduction

In this subsection, we shall learn the basics about placement of tables and inserting of figures. Headings must be placed above their associated tables, as shown in Table D.1.

Table D.1: Font Sizes For Papers

Font Size	Appearance		
	Regular	Bold	Italic
8	Table header (in Small Caps), figure caption, reference item		Reference item (partial)
9	Author email address, cell in a table, biography body	Abstract, body, biography author	Abstract heading (in bold)
10	Level-1 heading (in Small Caps), paragraph		Level-2 heading, Level-3 heading, author affiliation
11	Author name		
20	Title		

1.1 Figures

Latex cannot manage images by itself, so we need to use the `graphicx` package to insert Figures. To use it, we include the `graphicx` package in the preamble. One powerful attribute of Latex over word, is in its ability to manage figure placement within the body of the document.

When referencing a figure, the `\ref{. . }` command is used to refer to the specific figure file stored in the Latex Workshop folder. This function is used in the figure environment in Latex. Make sure all the figures to be referred to are store in the same folder where the `latex.tex` file is stored. In this training, all the figures and pictures have been stored in the same Latex workshop folder. To reference the figure below, use **Fig. D.1**

Here's another citation [2]

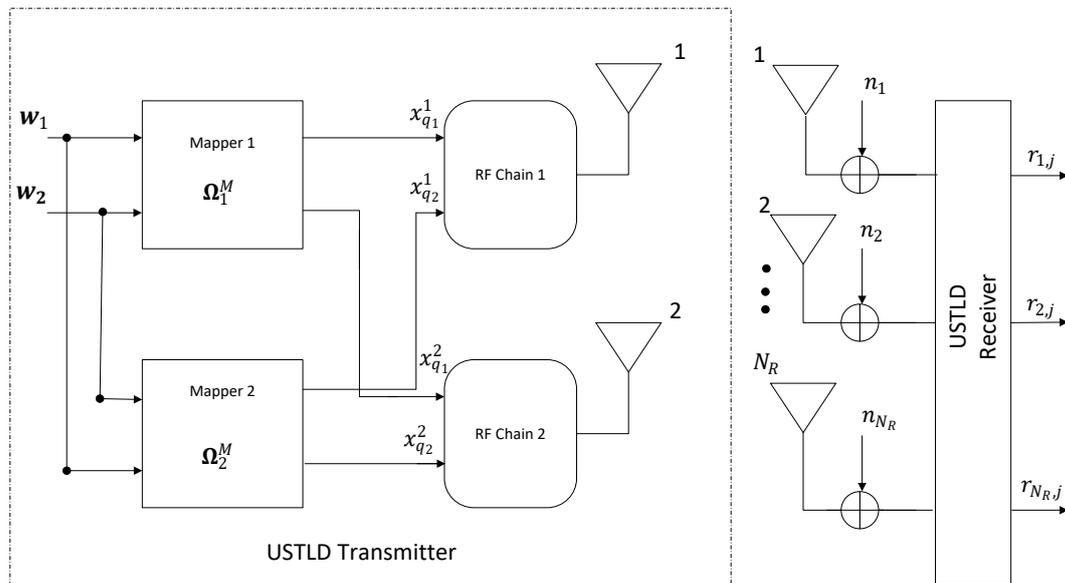


Fig. D.1: USTLD with two transmit antennas scheme [1]

2 Conclusion

References

- [1] H. Xu, K. Govindasamy, and N. Pillay, “Uncoded space-time labeling diversity,” *IEEE Communications Letters*, vol. 20, no. 8, pp. 1511–1514, Jun. 2016.
- [2] D. L. Baggio, *Mastering OpenCV with practical computer vision projects*. Packt Publishing Ltd, 2012.

Part III

Conclusion

1 Conclusion

Here's a citation [1]

and here's another citation [2]

References

- [1] A. A. Aburomman and M. B. I. Reaz, "Ensemble of binary svm classifiers based on pca and lda feature extraction for intrusion detection," in *Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), 2016 IEEE*. IEEE, 2016, pp. 636–640.
- [2] R. Berwick, "An idiot's guide to support vector machines (svms)," *Retrieved on October*, vol. 21, p. 2011, 2003.

Part I

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List of Publications

- [1] Dauda Ayanda and Hongjun Xu. A Unified Error Analysis of Uncoded Space-Time Labeling Diversity with Three Transmit Antennas in Rician Fading Channels. In *2019 IEEE 2nd Wireless Africa Conference (WAC)*, pages 1–5. IEEE, 2019.
- [2] Dauda Ayanda, Hongjun Xu, and Narushan Pillay. Uncoded M-ary Quadrature Amplitude Modulation Space-time Labeling Diversity with Three Transmit Antennas. *International Journal of Communication Systems*, 31(18, e3818), Dec. 2018.
- [3] Armeline D Mafuta and Tom Walingo. Interference Alignment for Transceiver Design in Multi-User MIMO Relay System. In *2018 IEEE 88th Vehicular Technology Conference (VTC-Fall)*, pages 1–5. IEEE, 2018.
- [4] Armeline Dembo Mafuta, Tom Walingo, and Fambirai Takawira. Interference Management in LTE-Advanced Cooperative Relay Networks: Decentralized Transceiver Design With Channel Estimation. *IEEE Access*, 7:131078–131093, Aug. 2019.
- [5] Louis Mothwa, Jules-Raymond Tapamo, and Temitope Mapati. Conceptual Model of the Smart Attendance Monitoring System Using Computer Vision. In *2018 14th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)*, pages 229–234. IEEE, 2018.