
Information Theory: Principles and Applications

MAP-I Curricular Unit in Theory and Fundaments

Summary

This document describes a Ph.D. level course intended as a Curricular Unit in Theory and Fundaments for the MAP-I Doctoral Programme in Informatics. It is offered jointly by (i) Departamento de Ciência de Computadores, Universidade do Porto and (ii) Departamento de Electrónica, Telecomunicações e Informática, Universidade de Aveiro. The objective is to expose students to the principles and practice of information theory, covering various topics in data/information compression, transmission, storage and processing, as well as cutting edge applications in the analysis, design and optimization of wireless systems and networks, sensor networks and network information flow. It is the intention to accredit the Curricular Unit in the Doctoral Programme of Carnegie Mellon University (CMU).

Instructors

Miguel Rodrigues (Coordinator)	DCC, FCUP	mrodrigues@dcc.fc.up.pt
José Vieira	DETI, UA	vieira@ua.pt

Course Objectives

The objective of the course is to expose students to the principles and practice of information theory, covering both theoretical and applied issues of recognized importance in data/information compression, transmission, storage and processing. The first part of the course covers the basic principles of information theory, including the basic theory and algorithms behind source and channel coding for single-user (point-to-point) and multi-user systems. The second part of the course covers advanced applications of information theory, including the analysis, design and optimization of wireless communications systems and networks, sensor networks, and network information flow.

This course covers material typical of various advanced modules at leading academic institutions in the field, namely:

- Information Theory, Thomas Cover, Stanford University
- Information Theory, Sergio Verdú, Princeton University
- Transmission of Information, Lizhong Zheng, MIT
- Information Theory, Michael Mecking, Technische Universität München
- Information Theory, Pierre Moulin, University of Illinois at Urbana-Champaign

Learning Outcomes

- Familiarity with the principles and applications of information theory in data compression, transmission, storage and processing, as well as in the analysis, design and optimization tool for wireless systems and networks, sensor networks, network information flow.
- Exposure to cutting-edge research topics in information theory and its applications.
- Ability to extract information from scientific papers in the field, and acquisition of technical writing and presentation skills.

Teaching Methods and Assessment

The course is composed by a series of lectures, discussions, and student assignments and presentations. In accordance with the philosophy of the course, the theoretical material will be complemented with specific application examples and case-studies. The student assessment is based on the following key components:

- 50% Final Exam
- 40% Assignments and Presentations
- 10% Class Participation

Course Content

The course consists of two parts: (i) principles and (ii) applications.

- **Part I: Principles**
 1. **Information Measures:** entropy; relative entropy; mutual information; Jensen's inequality; Fano's inequality; data processing inequality.
 2. **Source Coding:** asymptotic equipartition property; source coding theorem – achievability and converse; source coding algorithms – Huffman coding, Shannon-Fano-Elias coding, arithmetic coding, Lempel-Ziv coding.
 3. **Channel Coding:** joint asymptotic equipartition property; channel coding theorem – achievability and converse; channel coding and decoding algorithms – block codes, convolutional codes, Viterbi decoding, sequential decoding, belief propagation; joint source channel coding theorem; channel capacity with and without feedback.

4. **Rate Distortion Theory:** rate distortion function; rate distortion theorem – achievability and converse; channel capacity and rate distortion function computation algorithms.
5. **Multuser Information Theory:** multiple-access channel; broadcast channel; relay channel; Slepian-Wolf coding; source coding with side information; rate distortion with side information.

• **Part II: Applications**

1. **Wireless Systems and Networks:** fading channels capacity – the ergodic, block, and quasi-static fading channels; space-time coding; space-time multiplexing; diversity-multiplexing tradeoff.
2. **Sensor Networks:** sensing capacity; compressed sensing; distributed source coding; distributed inference.
3. **Network Information Flow:** routing versus network coding; network code construction; randomized network coding; network coding protocols.
4. **Advanced Coding Applications:** Coding in the real and complex number field; random codes; digital fountains; explicit and implicit graph (rateless) codes; LT and Raptor codes; joint source-channel coding; efficient and reliable downloads from multiple sources, distributed storage, multimedia broadcast.

Course Schedule

The course will be covered by Miguel Rodrigues (MR), José Vieira (JV), and invited lecturers (IL) with research contributions in selected topics.

Topic	I.1	I.2	I.3	I.4	I.5	II.1	II.2	II.3	II.4
No. of lectures	1	2	2	1	2	2	1	1	2
Instructor	MR	MR	MR	MR	MR	MR	IL	IL	JV

Bibliography

- T. M. Cover and J. A. Thomas. Elements of Information Theory, 2nd Edition. John Wiley & Sons, New York, 2006.
- R. G. Gallager. Information Theory and Reliable Communication. John Wiley & Sons, New York, 1968.
- R. W. Yeung. A First Course in Information Theory. Springer, New York, 2002.
- D. J. C. MacKay. Information Theory, Inference and Learning Algorithms. Cambridge University Press, Cambridge, 2003.

Instructor Team

The team of instructors is actively involved in research in the field of information theory, addressing both theoretical issues as well as cutting-edge applications of recognized importance, as evidenced by an extensive publication list with articles in various relevant IEEE Transactions and IEEE Conference Proceedings. A brief biography of the instructors is provided below:

Miguel Rodrigues: Miguel Rodrigues was born in Porto, Portugal on May 30, 1975. He received the Licenciatura degree in Electrical Engineering from the Faculty of Engineering of the University of Porto, Portugal in 1998 and the Ph.D. degree in Electronic and Electrical Engineering from University College London, U.K. in 2002.

From January 2003 to September 2006, he has held postdoctoral research appointments at Cambridge University, U.K., both as a Research Associate and later as a Senior Research Associate. From September 2006 to March 2007, he was a Visiting Researcher at Princeton University, U.S.A. He joined the faculty of the Department of Computer Science, Faculty of Sciences of the University of Porto as an Assistant Professor in March 2007. He is an Honorary Senior Researcher at University College London, U.K. He has also been a Visiting Researcher at Princeton University, U.S.A. in the summer of 2007.

His research interests include the general areas of information theory, communications theory, signal processing and optimization, and their applications to wireless and optical systems and networks. He has over 70 publications in international journals and conference proceedings in these areas. He has also been lecturing frequently abroad and has also served as a technical consultant to major international telecommunication companies.

Dr. Rodrigues has served on the technical programme committee of various international conferences. He has been the recipient of the the Prize Engenheiro António de Almeida, the Prize Engenheiro Cristiano Spratley, and the Merit Scholarship from the University of Porto, and the best student poster prize at the 2nd IMA Conference on Mathematics in Communications. He has also been the recipient of doctoral and postdoctoral fellowships from the Portuguese Foundation for Science and Technology, and a postdoctoral fellowship from Foundation Calouste Gulbenkian.

José Vieira: José Vieira was born in Aveiro, Portugal on September 4, 1963. He received the Licenciatura degree in Electrical Engineering from University of Coimbra, Portugal in 1988, the Master degree in Electrical Engineering from the same university in 1993 and the Ph.D. degree in Electrical Engineering from University of Aveiro, Portugal in 2000.

From 1989 to 1991, he was a research assistant at the University of Coimbra working on the development of a digital seismograph. In 1991 he joined the Electronics and Telecommunications Department at the University of Aveiro where he is an Assistant Professor.

His main research interest is the general area of digital signal processing with applications to audio and communications. The main topic of its Ph.D thesis was signal reconstruction and its relations with coding theory. He has been working on real number coding, compressed sensing and digital fountains. He is one of the founders of the Portuguese section of the Audio Engineering Society. He is also an active reviewer of several journals on the area of digital signal processing.

MIGUEL RAUL DIAS RODRIGUES

IDENTIFICAÇÃO PESSOAL

Nome: Miguel Raul Dias Rodrigues
Nacionalidade: Portuguesa
Endereço: Departamento de Ciência de Computadores
Faculdade de Ciências, Universidade do Porto
Rua Campo Alegre 1021/1055
4169-007 Porto, Portugal
Email: mrodrigues@dcc.fc.up.pt

HABILITAÇÕES ACADÉMICAS

1998-2002 **University College London** **Londres, Reino Unido**

Doctor of Philosophy in Electronic and Electrical Engineering

TESE: *Modelling and performance assessment of OFDM communication systems in the presence of non-linearities.*

ORIENTADORES: Prof. John O'Reilly e Prof. Izzat Darwazeh.

1997-1998 **UMIST** **Manchester, Reino Unido**

Master of Science in Communications Engineering (TOP STUDENT)

TESE: *Digital modulation techniques compared in a time varying and dispersive channel.*

ORIENTADOR: Prof. Geoffrey Gott.

1993-1998 **Faculdade de Engenharia da Universidade do Porto** **Porto, Portugal**

Licenciatura em Engenharia Electrotécnica e de Computadores (TOP STUDENT)

PRÉMIOS

- **Prémio de Melhor Poster (2002)**

Prémio atribuído ao poster *Volterra series assessment of non-linearly distorted OFDM signals: Error probability evaluation* (M. R. D. Rodrigues, I. Darwazeh and J. J. O'Reilly) apresentado na *2nd IMA International Conference on Mathematics in Communications* realizada em Lancaster no Reino Unido em Dezembro de 2002.

- **Prémio Engenheiro Cristiano Spratley (1999)**

Atribuído pela Faculdade de Engenharia da Universidade do Porto aos estudantes da Licenciatura de Engenharia Electrotécnica e de Computadores da mesma Faculdade com a classificação mais elevada.

- **Prémio Engenheiro António de Almeida (1999)**

Atribuído pela Fundação Engenheiro António de Almeida aos estudantes da Licenciatura de Engenharia Electrotécnica e de Computadores da Faculdade de Engenharia da Universidade do Porto com a classificação mais elevada.

- **Bolsa de Mérito (1996-1997)**

Atribuída pela Universidade do Porto aos estudantes da Faculdade de Engenharia da Universidade do Porto com as classificações mais elevadas.

EXPERIÊNCIA PROFISSIONAL

Mar. 2007 - presente **Faculdade Ciências Universidade do Porto** **Porto, Portugal**

Prof. Auxiliar Convidado, Departamento de Ciências de Computadores

Mar. 2007 - presente **Instituto de Telecomunicações** **Porto, Portugal**

Coordenador, Networks and Information Processing Group, Jan. 2008 - presente

Investigador, Networks and Information Processing Group, Mar. 2007-Dec. 2007

Jul. 2007 - Set. 2007 **Universidade de Princeton** **Princeton, NJ, EUA**

Visiting Researcher, Department of Electrical Engineering

Set. 2006 - Fev. 2007 **Universidade de Princeton** **Princeton, NJ, EUA**

Visiting Researcher, Department of Electrical Engineering

Jan. 2003 - Set. 2006 **Universidade de Cambridge** **Cambridge, Reino Unido**

Senior Research Associate, Computer Laboratory, Jan. 2006-Set.2006

Research Associate, Department of Engineering, Jan. 2004-Dez. 2005

Visiting Researcher, Department of Engineering, Jan. 2003-Dez. 2003

Nov. 2004 - Set. 2006 **Corpus Christi College** **Cambridge, Reino Unido**

Research Associate

Maio 2003-presente **University College London** **Londres, Reino Unido**

Honorary Senior Research Fellow, Dept. E&EE, Maio 2005-presente

Honorary Research Fellow, Dept. E&EE, Maio 2003-Maio 2005

EXPERIÊNCIA DE ENSINO

2007-presente **Universidade do Porto** **Porto, Portugal**

Coordenador da disciplina de Digital Communications do Programa Doutoral em Telecomunicações Minho-Aveiro-Porto, 1º semestre 2007-2008.

Regente da cadeira de *Teoria da Informação* do Mestrado Integrado de Engenharia de Redes e de Sistemas, Departamento de Ciência de Computadores, 1º semestre 2007-2008.

Regente da cadeira de *Comunicações Móveis* do Mestrado Integrado de Engenharia de Redes e de Sistemas, Departamento de Ciência de Computadores, 1º semestre 2007-2008.

Regente da cadeira de *Tópicos Avançados de Redes* do Mestrado Integrado de Engenharia de Redes e de Sistemas, Departamento de Ciência de Computadores, 2º semestre 2007-2008.

Regente da cadeira de *Tópicos Avançados de Redes* do Mestrado Integrado de Engenharia de Redes e de Sistemas, Departamento de Ciência de Computadores, 2º semestre 2006-2007.

Aulas práticas de *Paradigmas da Programação* da Licenciatura em Ciência de Computadores/Licenciatura em Engenharia de Redes e de Sistemas, Departamento de Ciência de Computadores, 2º semestre 2007-2008.

Aulas práticas de *Programação Estruturada* da Licenciatura em Ciência de Computadores/Licenciatura em Engenharia de Redes e de Sistemas, Departamento de Ciência de Computadores, 2º semestre 2006-2007.

Miguel Raul Dias Rodrigues

Abril 2008

2003-2006**Universidade de Cambridge****Cambridge, Reino Unido**

Aulas teórico-práticas de *Complexity Theory* ao 2º ano do *BA in Computer Science, Computer Laboratory*, 3º trimestre 2005-2006.

Aulas teórico-práticas de *Bioinformatics* ao 3º ano do *BA in Computer Science, Computer Laboratory*, 2º trimestre 2005-2006.

Aulas teórico-práticas de *Information Theory and Coding* ao 3º ano do *BA in Computer Science, Computer Laboratory*, 1º trimestre 2005-2006.

Aulas teórico-práticas de *Mathematical Methods* ao 1º ano do *BEng/MEng in Engineering, Department of Engineering*, 3º trimestre 2004-2005.

Aulas teórico-práticas de *Systems and Control* ao 3º ano do *BEng/MEng in Engineering, Department of Engineering*, 2º trimestre 2003-2004.

Aulas teórico-práticas de *Signals and Systems* ao 3º ano do *BEng/MEng in Engineering, Department of Engineering*, 1º trimestre 2003-2004.

Aulas teórico-práticas de *Data Transmission* ao 3º ano do *BEng/MEng in Engineering, Department of Engineering*, 1º trimestre 2003-2004.

1999-2006**University College London****Londres, Reino Unido**

Aulas teóricas no *Mobile and Personal Communications Module* do *MSc in Telecommunications, Department of Electronic and Electrical Engineering*, 2002-2006.

Aulas teóricas no *Communications Systems Modelling Module* do *MSc in Telecommunications, Department of Electronic and Electrical Engineering*, 2002-2006.

Aulas laboratoriais no *Communications Systems Modelling Laboratory* do *MSc in Telecommunications, Department of Electronic and Electrical Engineering*, 2001-2002.

Aulas laboratoriais no *Technologies for Broadband Communications Laboratory* do *MSc in Broadband Communications, Department of Electronic and Electrical Engineering*, 2001-2002.

Aulas laboratoriais no *Microwave and Opto-Electronics Laboratory* do *MSc in Microwave and Opto-Electronics, Department of Electronic and Electrical Engineering*, 1999-2001.

EXPERIÊNCIA DE CONSULTORIA**Jan.-Mar. 2004****Enertel****Roterdão, Holanda**

Consultor para um dos principais operadores de telecomunicações holandeses, sendo responsável por aconselhar e formar uma equipa de engenheiros sobre os vários aspectos tecnológicos de redes de acesso sem-fios de banda larga. A Enertel implementou desde então uma rede de acesso sem-fios de banda larga com bastante sucesso.

INTERESSES DE INVESTIGAÇÃO

Teoria da informação, teoria da comunicação, processamento de sinal e optimização. Redes e sistemas de comunicações móveis e comunicações ópticas.

BOLSAS DE INVESTIGAÇÃO

- Bolsa de pós-doutoramento atribuída pela Fundação Calouste Gulbenkian para a realização de um pós-doutoramento na Universidade de Princeton (Set. 2003-Fev. 2003).
- Bolsa de pós-doutoramento atribuída pela Fundação para a Ciência e a Tecnologia para a realização de um pós-doutoramento na Universidade de Cambridge (Jan. 2003-Dec. 2003).
- Bolsa de doutoramento atribuída pela Fundação para a Ciência e a Tecnologia para a realização de um doutoramento no University College London (Oct. 1998-Oct. 2002).

PROJECTOS DE INVESTIGAÇÃO

- *Foundations of Future Wireless Communications Systems: Analysis, Design and Optimization*. Projecto financiado pela Fundação Luso-Americana entre Jan. 2008–Dez. 2010. Investigador Principal.
- *Wireless information-theoretic security*. Projecto financiado pela Fundação para a Ciência e a Tecnologia entre Jan. 2008–Dez. 2010. Membro da equipa de investigação.
- *Design and optimisation of WDM millimetre-wave fibre-radio systems*. Projecto financiado pela Fundação para a Ciência e a Tecnologia entre Out. 2007–Set. 2009. Membro da equipa de investigação.
- *Bandwidth efficient multi-carrier systems for wireless communications*. Projecto financiado pelo *Engineering and Physical Sciences Research Council* (EPSRC) entre Out. 2006–Set. 2009. Membro da equipa de investigação.
- *Broadband fixed wireless access: capacity and throughput improvement techniques*. Projecto financiado pelo *Engineering and Physical Sciences Research Council* (EPSRC) entre Jan. 2004–Dez. 2006. Membro da equipa de investigação.

ORIENTAÇÕES DE DOUTORAMENTO

- Ioannis Kanaras, aluno de doutoramento do Department of Electronic and Electrical Engineering, University College London. Co-orientação com o Prof. Izzat Darwazeh. Projecto: 'Bandwidth efficient multi-carrier systems for wireless communications'. Out. 2006-presente.
- João Manuel Barbosa de Oliveira, aluno de doutoramento do Departamento de Engenharia Electrotécnica e de Computadores da Faculdade de Engenharia da Universidade de Porto, Portugal. Co-orientação com o Prof. Henrique Salgado. Projecto: 'Fibre Bragg gratings analysis, design and optimisation for WDM millimetre-wave fibre-radio systems'. Jan. 2006-presente.
- William Carson, aluno de doutoramento do *Computer Laboratory* da Universidade de Cambridge, Reino Unido. Co-orientação com o Prof. Ian Wassell. Projecto: 'Iterative detection techniques for wireless communications'. Jan. 2006-presente.
- Jaime Adeane, aluna de doutoramento do *Department of Engineering* da Universidade de Cambridge, Reino Unido. Co-orientação com o Prof. Ian Wassell. Tese: 'Spatial diversity in wireless communications: Multiple antenna systems and virtual antenna arrays'. Grau de doutoramento conferido em 2007.
- Ioannis Chatzigeorgiou, aluno de doutoramento do *Department of Engineering* da Universidade de Cambridge. Co-orientação com o Prof. Ian Wassell. Tese: 'Performance analysis and design of punctured turbo codes'. Grau de doutoramento conferido em 2007.

ORIENTAÇÕES DE MESTRADO

- Hugo Reboredo, aluno de mestrado do Departamento de Engenharia Electrotécnica da Faculdade de Engenharia da Universidade do Porto, Portugal. Co-orientação com o Prof. Henrique Salgado. Projecto: 'Turbo processing techniques for optimal communications systems'. Set. 2007-presente.

BOLSEIROS

- Pedro Almeida, aluno de mestrado do Departamento de Matemática Pura da Faculdade de Ciências da Universidade do Porto. Projecto: 'Wireless information-theoretic security'.

ATIVIDADES PROFISSIONAIS

- *Publications Chair*, 2008 IEEE Information Theory Workshop, Porto, Portugal
- *Technical Programme Committee Member*, 2008 IEEE International Conference on Broadband Communications, Networks and Systems, London, U.K.
- *Technical Programme Committee Member*, 2008 IEEE Vehicular Technology Conference-Spring, Singapore
- *Technical Programme Committee Member*, 2008 IET Conference Wireless, Mobile, Multimedia Networks, Mumbai, India
- *Technical Programme Committee Member*, 2005 European Conference on Networks & Optical Communications, London, U.K.
- Revisor de várias revistas internacionais (*IEEE Transactions on Signal Processing*, *IEEE Transactions on Communications*, *IEEE Transactions on Wireless Communications*, *IEEE Transactions on Vehicular Technology*, *IEEE Transactions on Circuits and Systems I*, *IEEE Communications Letters*, *European Transactions on Telecommunications*, *IEE Proceedings-Communications*, *Electronics Letters*) e várias conferências internacionais (e.g., *IEEE International Symposium on Information Theory*, *IEEE International Conference on Communications*, *IEEE Global Telecommunications Conference*).
- *Comissão Científica* do Programa Doutoral em Ciência de Computadores, do Departamento de Ciência de Computadores da Faculdade de Ciências da Universidade do Porto.
- *Comissão Executiva* do MAP-I Programa Doutoral em Informática das Universidades do Minho, Aveiro e Porto.

PUBLICAÇÕES

Teses

1. M. R. D. Rodrigues. *Modelling and performance assessment of OFDM communication systems in the presence of non-linearities*. PhD Thesis, University College London, London, U.K., October 2002.
2. M. R. D. Rodrigues. *Digital modulation techniques compared in a time varying and dispersive channel*. MSc Thesis, UMIST, Manchester, U.K., September 1998.

Capítulos em livros

3. P. Xiao, I. Chatzigeorgiou, M. R. D. Rodrigues, R. Carrasco and I. J. Wassell. *Design Considerations and Algorithms for Broadband Fixed WiMAX Systems*. NOVA Publishers.

Artigos em revista científicas (publicados, submetidos e em preparação)

4. F. Pérez-Cruz, M. R. D. Rodrigues and S. Verdú. *Optimal precoding for multiple-input multiple-output Gaussian channels with discrete input distributions*. IEEE Transactions on Information Theory, in preparation.
5. M. R. D. Rodrigues and P. D. M. Almeida. *Filter design with secrecy constraints: The degraded parallel Gaussian wiretap channel*. IEEE Transactions on Information Theory, submitted.
6. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *Analysis and design of punctured rate-1/2 turbo codes exhibiting low error floors*. IEEE Transactions on Information Theory, submitted.
7. I. A. Chatzigeorgiou, A. Demosthenous, M. R. D. Rodrigues and I. J. Wassell. *On the performance-complexity tradeoff of convolutional codes for broadband FWA systems*. IEEE Transactions on Broadcasting, submitted.

8. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *The augmented state diagram and its applications to convolutional and turbo codes*. IEEE Transactions on Communications, first round of reviews.
9. M. Bloch, J. Barros, M. R. D. Rodrigues and S. W. McLaughlin. *Wireless information-theoretic security*. IEEE Transactions on Information Theory - Special Issue on Information-Theoretic Security, accepted.
10. M. R. D. Rodrigues, I. A. Chatzigeorgiou, I. J. Wassell and R. A. Carrasco. *Performance analysis of turbo codes in quasi-static fading channels*. IEE Proceedings-Communications, accepted.
11. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *A comparison of convolutional and turbo coding schemes for broadband FWA systems*. IEEE Transactions on Broadcasting, vol. 53, pp. 494-503, June 2007.
12. J. A. Adeane, M. R. D. Rodrigues and I. J. Wassell. *Lattice reduction based detection techniques for MIMO-OFDM-CDM communication systems*. IEE Proceedings-Communications, vol. 56, pp. 526-531, June 2007.
13. J. A. Adeane, M. R. D. Rodrigues and I. J. Wassell. *Centralised and Distributed Power Allocation for Cooperative Networks*. Electronics Letters, vol. 43, pp. 39-40, January 2007.
14. M. R. D. Rodrigues and I. J. Wassell. *IMD reduction with SLM and PTS to improve the error probability performance of non-linearly distorted OFDM signals*. IEEE Transactions on Vehicular Technology, vol. 55, pp. 537-548, March 2006.
15. M. R. D. Rodrigues and I. J. Wassell. *IMD reduction coding to improve the error probability performance of non-linearly distorted OFDM signals*. IEE Proceedings-Communications, vol. 152, pp. 559-566, October 2005.
16. M. R. D. Rodrigues, I. Darwazeh and J. J. O'Reilly. *Volterra-series-based analytic technique to assess the power density spectrum of nonlinearly distorted OFDM signals*. IEE Proceedings-Communications, vol. 151, pp. 401-407, August 2004.
17. M. R. D. Rodrigues, I. Darwazeh and J. J. O'Reilly. *Error probability behaviour of nonlinearly distorted OFDM signals*. IEE Electronics Letters, vol. 39, pp. 1620-1622, October 2003.

Artigos em actas de encontros científicos

18. F. Pérez-Cruz, M. R. D. Rodrigues and S. Verdú. *Optimal precoding for digital subscriber lines*. Proceedings of the IEEE International Conference on Communications, Beijing, China, May 2008.
19. M. R. D. Rodrigues, F. Pérez-Cruz and S. Verdú. *Multiple-input multiple-output Gaussian channels: Optimal covariance for non-Gaussian inputs*. Proceedings of the IEEE Information Theory Workshop, Porto, Portugal, May 2008.
20. W. R. Carson, I. J. Wassell and M. R. D. Rodrigues. *Modelling the frame error rate for iterative demapping and decoding techniques over quasi-static fading channels*. Proceedings of the IEEE Sarnoff Symposium, Princeton, N.J., U.S.A., April 2008.
21. F. Pérez-Cruz, M. R. D. Rodrigues and S. Verdú. *Generalized mercury/waterfilling for multiple-input multiple-output channels*. Proceedings of the 45th Allerton Conference on Communication, Control, and Computing, Monticello, Illinois, U.S.A., September 2007.
22. J. M. B. Oliveira, M. R. D. Rodrigues and H. M. Salgado. *Optimum receivers for non-linear distortion compensation of OFDM signals in fiber supported wireless applications*. Proceedings of the 2007 IEEE International Topical Meeting on Microwave Photonics, Victoria, B.C., Canada, October 2007.
23. W. R. Carson, I. A. Chatzigeorgiou, I. J. Wassell, M. R. D. Rodrigues and R. A. Carrasco. *On the performance of iterative demapping and decoding over quasi-static fading channels*. Proceedings of the IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, Athens, Greece, September 2007.
24. J. M. B. Oliveira, M. R. D. Rodrigues and H. M. Salgado. *Non-linear distortion compensation of OFDM signals in radio-over-fiber systems*. Proceedings of the V Symposium on Enabling Optical Networks and Sensors, Aveiro, Portugal, June 2007.
25. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *Pseudo-random Puncturing: A Technique to Lower the Error Floor of Turbo Codes*. Proceedings of the IEEE International Symposium on Information Theory, Nice, France, June 2007.

26. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *A Union Bound Approximation for Rapid Performance Evaluation of Punctured Turbo Codes*. Proceedings of the 41st Annual Conference on Information Sciences and Systems, Baltimore, Maryland, U.S.A., March 2007.
27. M. Bloch, J. Barros, M. R. D. Rodrigues and S. W. McLaughlin. *Good codes are good for security: information theoretic security for Gaussian and wireless channels*. Proceedings of the Information Theory and Applications Workshop, San Diego, California, U.S.A., January-February 2007.
28. M. Bloch, J. Barros, M. R. D. Rodrigues and S. W. McLaughlin. *LDPC-based secure wireless communication with imperfect knowledge of the eavesdropper's channel*. Proceedings of the IEEE Information Theory Workshop, Chengdu, China, October 2006.
29. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *Can punctured rate-1/2 turbo codes achieve a lower error floor than their rate-1/3 parent codes?* Proceedings of the IEEE Information Theory Workshop, Chengdu, China, October 2006.
30. M. Bloch, J. Barros, M. R. D. Rodrigues and S. W. McLaughlin. *An opportunistic physical-layer approach to secure wireless communications*. Proceedings of the 44th Allerton Conference on Communication, Control, and Computing, Monticello, Illinois, U.S.A., September 2006.
31. J. M. B. Oliveira, H. M. Salgado and M. R. D. Rodrigues. *Large signal analysis of Mach-Zehnder modulator intensity response in a linear dispersive fiber*. Proceedings of the London Communications Symposium 2006, London, U.K., September 2006.
32. M. R. D. Rodrigues and I. Darwazeh. *A spectrally efficient frequency division multiplexing based communications system*. Proceedings of the International Symposium on Broadband Communications, Moscow/St. Petersburg, September 2006.
33. J. Barros and M. R. D. Rodrigues. *Secrecy capacity of wireless channels*. Proceedings of the IEEE International Symposium on Information Theory, Seattle, Washington, U.S.A., July 2006.
34. João Oliveira, H. M. Salgado and M. R. D. Rodrigues. *Large signal analysis of Mach-Zehnder modulator intensity response in a dispersive fiber*. Proceedings of the IV Symposium on Enabling Optical Networks and Sensors, Porto, Portugal, June 2006.
35. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *A novel technique to evaluate the transfer function of punctured turbo codes*. Proceedings of the IEEE International Conference on Communications, Istanbul, Turkey, June 2006.
36. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *A novel technique for the evaluation of the transfer function of parallel concatenated convolutional codes*. Proceedings of the 4th International Symposium on Turbo Codes, Munich, Germany, April 2006.
37. I. A. Chatzigeorgiou, M. R. D. Rodrigues, I. J. Wassell and R. A. Carrasco. *Punctured binary turbo-codes with optimized performance*. Proceedings of the IEEE Vehicular Technology Conference-Fall, Dallas, Texas, U.S.A., vol. 3, pp. 1965-1969, September 2005.
38. M. R. D. Rodrigues, I. A. Chatzigeorgiou, I. J. Wassell and R. A. Carrasco. *On the performance of turbo codes in quasi-static fading channels*. Proceedings of the IEEE International Symposium on Information Theory, Adelaide, Australia, pp. 622-626, September 2005.
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2. *Optimum resource allocation in MIMO systems: An information theoretic-estimation theoretic approach*. Department of Electronic and Electrical Engineering, University College London, London, U.K., November 2007, Host: Izzat Darwazeh.
3. *Optimum resource allocation in MIMO systems: An information theoretic-estimation theoretic approach*. Computer Laboratory, University of Cambridge, Cambridge, U.K., November 2007, Host: Ioannis Chatzigeorgiou.
4. *Optimum resource allocation in MIMO systems: An information theoretic-estimation theoretic approach*. Departamento de Engenharia Electrotécnica e de Computadores, Instituto Superior Técnico, Lisboa, Portugal, November 2007. Host: João Luís Sobrinho.
5. *Optimum power allocation for MIMO systems with discrete input distributions: An information theoretic-estimation theoretic approach*. Bell Laboratories, Murray Hill, New Jersey, U.S.A., September 2007. Host: Emina Soljanin.
6. *Resource optimization in communications systems: An information theoretic-estimation theoretic approach*. Departamento de Matemática Aplicada, Faculdade de Ciências da Universidade do Porto, Porto, Portugal, May 2007. Host: Maria Eduarda Silva.

7. *Wireless communications revolution: From reliability to security.* Departamento de Engenharia Electrotécnica e de Computadores, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal, June 2006. Host: Henrique Salgado.
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9. *Cooperative networks for wireless communications.* Departamento de Electrónica e Telecomunicações, Universidade de Aveiro, Aveiro, Portugal, June 2006. Host: José Vieira.
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SEMINÁRIOS

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2. *Secrecy rate of wiretap channels with arbitrary inputs,* 3º Seminário da Rede Temática em Segurança da Informação, Porto, Portugal, Dezembro 2008.

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