EURASIP

NEWS LETTER

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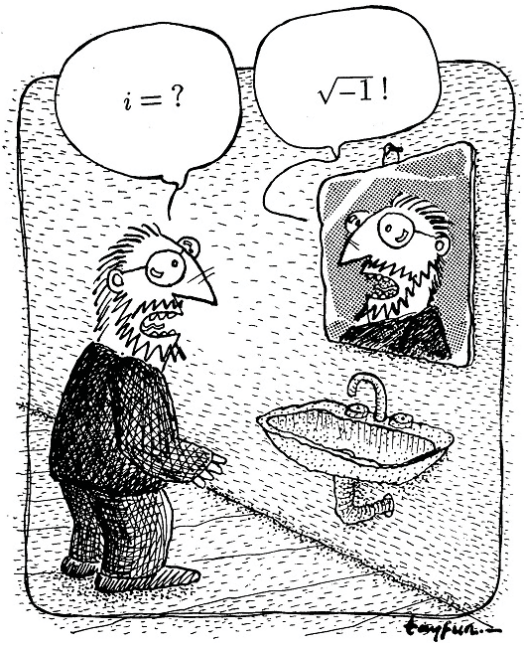

European Association for Signal Processing

Newsletter, Volume 21, Number 1, March 2010

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President's Message

This is the first EURASIP Newsletter of 2010. During the past year a lot of new movements started in EURASIP to improve further community services. After establishing reduced fees for our members when publishing in our open access journals and reduced conference fees for our cooperated workshops, we were offering discount offers on books from Elsevier. We re-launched the EURASIP PhD library, now with many hundreds of recent European PhDs. It is a free service and I invite everyone to uploading their PhD thesis up there for free downloads. Please check under www.eurasip.org. As we made it a policy that our supported conferences either have their papers on our EURASIP Open Library or on IEEE Xplore, the amount of papers in our library keeps growing.

A second strong movement in the last year was the appointment of more than 50 European Liaisons that help distributing the EUSIPCO movement directly into the heart of our community. With more local people actively involved in our signal processing community we hope to address the needs of our members even better than in the past. To this extend we sponsored several local seminars of well known speakers like Simon Haykin and Sergios Theodoridis to name a few and made their slides freely available. Note that every member of EURASIP can request seminar funding and it certainly helps to know your next local Liaison person. Note that all work for EURASIP is a voluntary work and we intend to keep it this way since we can wholeheartedly claim that none of your membership fee goes into personal pockets but is returned at 100% to our community.

A new addition of our service has recently been established: the EURASIP JOP POST that allows members to offer job opportunities in signal processing. We believe that such service may become very useful in the future and in particular at those times when it is hard to find jobs for qualified people. For the coming year we want to inspire more discussion with the community to understand better in which way EURASIP can help. To achieve this we started a EURASIP linkedin group which you are invited to join. With this issue we also invite to send letters to the editor, where we want to offer community members to write what is deeply moving you these days in the field of signal processing to share your ideas with others.

A lot of preparation is now ahead for the upcoming event the EUSIPCO 2010 in Aalborg, Denmark. Søren Holdt Jensen is feverishly working on making it becoming the successful event that is has been in the past. As in past years we will offer free tutorials during the first day as it has become a great success with many hundred participants. Outstanding plenary speakers as well as new EURASIP fellows will mark the programme. Check frequently the web page www.eusipco2010.org for updates.

In spite of all changes—some already made and some expected—we intend to keep what we are, EURASIP, a friendly and open society for Signal Processing.

I wish all EURASIP members a happy and successful 2010.

Markus Rupp
EURASIP President

A Newsletter for the Signal Processing Community

Dear Signal Processing Community,

We would like to expand the scope of our quarterly EURASIP newsletter to become a platform for exchange of professional views and for the dissemination of news of signal processing related happenings through which we envision a bigger involvement of EURASIP members in the signal processing community affairs. Some suggestions for an enriched newsletter content that is relevant for the signal processing communities are:

- Opening of new signal processing laboratories
- Success stories and breakthroughs of teams of researchers in signal processing
- Celebrations, retirements and commemorations
- Letters to the editor, for example comments on EURASIP conferences, envisioned EURASIP activities, suggestions for our Newsletter content, feedback on EURASIP
- Announcements on signal processing-based products
- Innovations on DSP education (for example discussion on the Bologna process in your country or the recent DSP curriculum)
- Invitations for collaborations on international level (for example COST actions, STREP proposals, EUREKA initiatives)
- Or simply new ideas . . .

Please send all your criticisms, suggestions and ideas to our Newsletter editor Ann Spriet: ann.spriet@esat.kuleuven.be.

Looking forward to receiving your ideas.

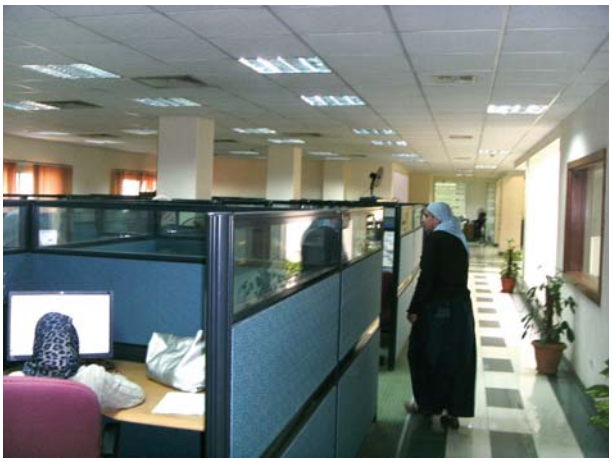
Markus Rupp
EURASIP President

A Visit to Hindawi Publishing Corporation in Cairo, Egypt

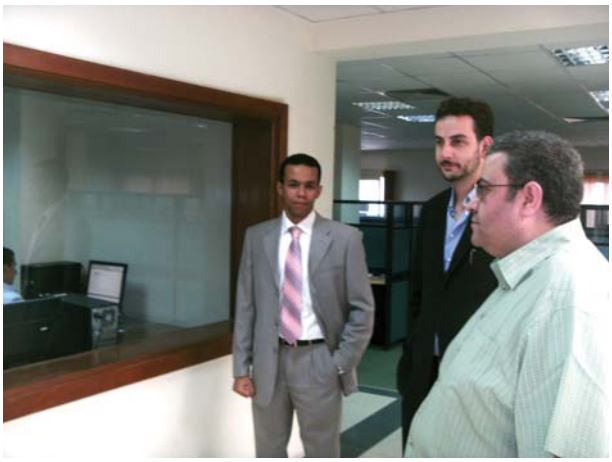
Coming to Egypt is a big adventure, traveling to Cairo is an even bigger one, but visiting Ahmed Hindawi in his publishing house established in 1997 was even more surprising. When I was invited by Cairo University to be part in the PhD defense of Mostafa Ibrahim, I took the opportunity to visit Hindawi in Cairo. Currently, some 215 journals are being handled there, and their number is growing steadily, among them our seven EURASIP journals.

Picture of Hindawi's office.

Hindawi is right now offering some 300 people a job and the demand for employees is growing as the submission rate doubled last year. The building that Hindawi owns was recently expanded in order to add three additional floors, and now the fifth floor is being refurbished to accommodate more people who were recently hired. The majority of the employees at Hindawi have a university degree.



Pictures of building interior.



Picture showing Ahmed Hindawi, Paul Peters, and Mohamed Hamdy.

You may ask why so many people are needed to publish your paper. Well, let's have a closer look into Hindawi's business. Once your paper is submitted, then what happens?

You may have been contacted by one of their in-house editorial staff who are responsible for monitoring each submission until a final decision is made; if any problems occur, they intervene to help resolve the situation. For Hindawi, one of the greatest benefits that has come from their investment in technology is the ability of the editorial staff to interact directly with editors, authors, and reviewers to ensure that the peer-review process runs as smoothly as possible.

But what happens when the paper gets accepted?

First the sources, typically latex are the starting point. From here, three groups work in parallel to speed up the publication process. The first group converts the latex text and equations into an XML format, which will then serve as the final archival format of the published article. The second group converts the figures into something that looks pleasant. Here all legends are ripped off, the figures being adjusted to the right size, and the lines redrawn so that they always appear the same way. Finally the legends are added by hand using the same fonts as in the text. Finally, the third group works on the references, checking each and every one of them for correctness and bringing them into the right format.

Omnia Hassan: Graphics Specialist.

Now the copy-editing group goes over the text and checks for inconsistencies and possible flaws in English language. Obvious errors are being corrected, some doubtful ones get marked and comments are added for the authors to check in the first round of galley proofs. Once the proof reading process is over, the paper is finalized in an XML format. From here different versions of the content are derived from the single XML source file, including the PDF version as well as the online HTML version. In addition, there is a third format that is produced, known as ePUB, which is capable of reflowing in order to fit any screen resolution. On a small cell phone screen with only QVGA resolution, it displays an article in a single column, which is entirely different than if you have a high resolution screen. And if you have even one of the new wide screens you may find a three column paper rather than a classical two column version. Hindawi claims that with this way of flexible format he can support our papers even in a hundred years from now. We will be happy to check that statement.

Screenshots of an article in ePub format showing the article in one, two, and three columns.

Lunch with Hindawi staff members: (from left to right) Hesham Youssef, Paul Peters, Markus Rupp, Mohamed Hamdy, Ahmed Hindawi, Muhammad Salah, and Fatma Sultan.

Talking about Egypt, one topic never should be missed, that is the hospitality and friendliness of the people. You may be burnt by the sun or covered by dust and sand but you will never feel hungry there.

For me personally it was not only a big adventure but a very welcome experience, hopefully not the last in this country.

Markus Rupp
EURASIP President

Workshop and Conference Activities

A good conference requires a long-term planning and dedicated volunteers. Many of us devote much time and effort to organising conferences and workshops so that we can present our new research findings, meet friends and discover new places. The success of a conference or Workshop does not depend on their preparation only, but also and most importantly on the keynote and tutorial speakers, the special sessions and your contribution.

The next flagship conference of EURASIP, the 18th European Signal Processing Conference (EUSIPCO 2010) will take place in Aalborg, Denmark, from 23 to 27 August 2010. The General Chair, Søren Holdt Jensen, and his General Co-Chair, Mats Viberg, together with their team, selected outstanding plenary speakers and received high-quality special session proposals from leading researchers on timely and most interesting topics. Some of the information is already available at the following address: http://www.eusipco2010.org/. The success of the conference will greatly depends on your paper submissions, which I hope will be accepted for presentation.

In this issue of the newsletter you will find a calendar of events, which lists forthcoming workshops or conferences that are co-sponsored by EURASIP. Some Calls for Papers are also included. Among these you will find the CFP for the forthcoming EUSIPCO conferences. AdCom would like to receive proposals for future EUSIPCO conferences beyond 2013. I would be delighted to receive an e-mail indicating your interest in organising EUSIPCO 2014 or EUSIPCO 2015.

Abdelhak Zoubir
EURASIP Event Coordinator

Calendar of Events

Year	Date	Event	Location	EURASIP Involvement	Chairperson/Information
2010	March 3–5	The 4th International Symposium on Communications, Control and Signal Processing (ISCCSP 2010)	Limassol, Cyprus	Co-sponsor	Stavros Zenios http://www.cut.ac.cy/isccsp2010/
	April 12–14	The 11th International Workshop on Image Analysis for Multimedia Interactive Services (WIAMIS 2010)	Desenzano del Garda, Italy	Co-sponsor	Pierangelo Migliorati http://www.wiamis2010.org/
	May 10–13	The 10th International Conference on Information Sciences, Signal Processing and their Applications (ISSPA 2010)	Kuala Lumpur, Malaysia	Co-sponsor	Boualem Boashash http://www.isspa2010.com/
	June 14-15	The 2nd IAPR International Workshop on Cognitive Information Processing (CIP 2010)	Elba Island, Italy	Co-sponsor	Fulvio Gini http://www.conference.iet.unipi.it/cip2010/
	June 20–23	The 11th IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC 2010)	Marrakech, Morocco	Co-sponsor	Mounir Ghogho http://www.spawc2010.org/
	June 23–25	The 8th International Workshop on Content-Based Multimedia Indexing (CBMI 2010)	Grenoble, France	Co-sponsor	Franck Thollard http://mrim.imag.fr/cbmi2010/
	June 30– July 2	The 4th International Conference on Image and Signal Processing (ICISP 2010)	Trois-Rivières, Québec, Canada	Co-sponsor	Olivier Lezoray http://www.uqtr.ca/~icisp/
	July 5–6	The 2nd European Workshop on Visual Information Processing (EUVIP 2010)	Paris, France	Co-sponsor	Azeddine Beghdadi http://www-l2ti.univ-paris13.fr/~euvip/
	July 7–10	The 2nd International Conference on Image Processing Theory, Tools and Applications (IPTA 2010)	Paris, France	Co-sponsor	Khalifa Djemal http://ipta10.ibisc.univ-evry.fr/
	July 21–23	The 7th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP 2010)	Newcastle, UK	Co-sponsor	Fary Ghassemlooy http://www.csndsp.com/
	August 23–27	The 18th European Signal Processing Conference (EUSIPCO 2010)	Aalborg, Denmark	Sponsor	Søren Holdt Jensen http://www.eusipco2010.org/
	September 6-7	The Third International EURASIP Workshop on RFID Technology (RFID 2010)	La Manga del Mar Menor, Cartagena, Spain	Co-sponsor	Javier Vales-Alonso http://www.ait.upct.es/EURASIP-RFID2010/
2011	August 29– September 2	The 19th European Signal Processing Conference (EUSIPCO 2011)	Barcelona, Spain	Sponsor	Ana Perez Neira http://www.eusipco2011.org/
2012	August 27–31	The 20th European Signal Processing Conference (EUSIPCO 2012)	Bucharest, Romania	Sponsor	Béatrice Pesquet-Popescu http://www.eusipco2011.org/

Abdelhak Zoubir; EURASIP Event Coordinator

Report on 3rd International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP 09)

Special "underwater session", Aruba.

The 3rd International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP09) was successfully held in Aruba, Dutch Antilles.

Over 100 researchers from more than 25 countries met together in this fantastic location in the very heart of the southern Caribbean. One of the Caribbean's most popular island destinations, Aruba is at once breathtakingly serene and dramatically rugged. Aruba's southern and western coasts are famous for their white beaches framed by swaying palm trees. All these provided a suitable ground for the CAMSAP09. The workshop was sponsored by the Sensor Array and Multi-channel Signal Processing Technical Committee of the IEEE Signal Processing Society and technically sponsored by EURASIP.

The workshop featured 12 invited sessions and 5 contributed sessions including many presentations by world-class speakers. In addition, we were fortunate to have a team of world-renowned plenary speakers. Fred Daum (Raytheon, USA) presented a physics based approach to nonlinear filters. Bart De Moor (KU Leuven, Belgium) talked about multilinear

rank approximation problems and extremal eigenvalue problems. Erik G. Larsson (Linkoping University, Sweden) explored the role of game theory in resource allocation. Rabinder Madan (Office of Naval Research, Arlington, VA, USA) introduced the latest trends in radar sensor information fusion. Shoji Makino (University of Tsukuba, Japan) addressed blind separation of convolutive mixtures of audio signals received by acoustic arrays. And, Arye Nehorai (Washington University, USA) gave a presentation on the statistical design of 3D microarrays with position-encoded microspheres.

The participants enjoyed free access to both wired and wireless networks, free welcome reception, free breakfast and lunches in cosy environment, and a memorable "dancing and smoking" banquet at the pool deck of the Radisson Aruba Resort.

Smiling faces at the welcome reception.

Maria Sabrina Greco, February 1, 2010




Call For Papers

Fourth INTERNATIONAL SYMPOSIUM ON COMMUNICATIONS, CONTROL AND SIGNAL PROCESSING

Grand Resort Hotel, Limassol, Cyprus

March 3-5, 2010

Organizing Committee

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Stavros Zenios, *Cyprus*

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Christoforos Hadjicostis, *Cyprus*

Local Arrangements Co-Chairs
Charalambos Charalambous, *Cyprus*
Andreas Lanitis, *Cyprus*

The 4th International Symposium on Communications, Control and Signal Processing (ISCCSP 2010) will be held in Limassol, Cyprus. It is intended to be a forum for technical exchange amongst scientists having interests in these areas. The technical program will include plenary lectures, regular technical sessions, and special sessions covering the three major tracks.

Cyprus is the third largest island of the Mediterranean. With a rich history traced back over nine thousand years, it has been invaded and claimed over the centuries by a fascinating mixture of civilizations all of which have left their culture and shaped its character. Considered to be the birthplace of Aphrodite, it is a primary tourist destination blessed with natural beauty that ranges from golden beaches and rugged coastlines to rolling hills and forest clad mountains, dotted with picturesque villages.

Prospective authors are invited to submit full-length, four page original papers in portable document format (PDF) to the ISCCSP Technical Program Committee. All papers will be handled and reviewed electronically. Proceedings of the Symposium will be published and provided to attendees on electronic media. Please note that at least one full paying author of each accepted paper must register for the Symposium before the indicated deadline.

SCHEDULE FOR AUTHORS

Submission of papers opens	July 24, 2009
Deadline for submission of papers	October 9, 2009
Notification of acceptance	December 7, 2009
Deadline for author registration	January 8, 2010

Conference website:
http://www.cut.ac.cy/isccsp2010

International Technical Program Committee

Driss Aboutajdine, *Morocco*
Andreas Antoniou, *Canada*
Jaakko Astola, *Finland*
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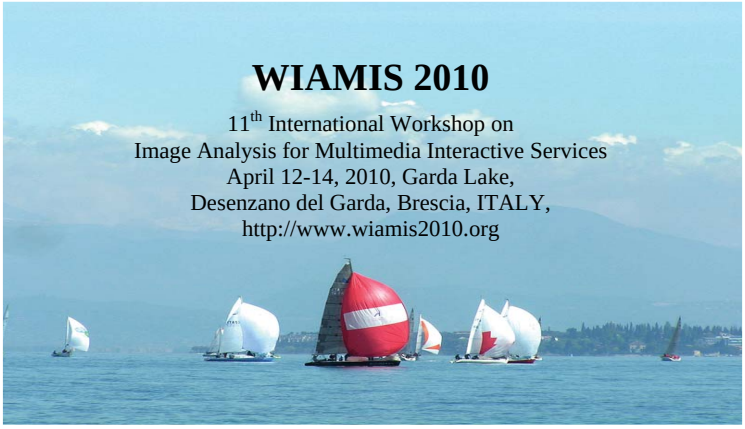
Technical Sponsor
IEEE Signal Processing Society
EURASIP



WIAMIS 2010 Call for Papers

The International Workshop on Image Analysis for Multimedia Interactive Services is one of the main international events for the presentation and discussion of the latest technological advances in interactive multimedia services. The objective of the workshop is to bring together researchers and developers from academia and industry working in the areas of image, video and audio applications, with a special focus on analysis. After a series of successful meetings starting in 1997 in Louvain, WIAMIS 2010 will be held in Desenzano del Garda, by the beautiful Garda Lake, Italy.

Topics of interest include, but are not limited to:

- Multimedia content analysis and understanding
- Content-based browsing, indexing and retrieval of images, video and audio
- Content-based copy detection
- Emotional based content classification and organization
- 2D/3D feature extraction
- Advanced descriptors and similarity metrics for audio and video
- Relevance feedback and learning systems
- Segmentation of objects in 2D/3D image sequences
- Motion analysis and tracking
- Video analysis and event recognition
- Analysis for coding efficiency and increased error resilience
- Analysis and tools for content adaptation
- Multimedia content adaptation tools, transcoding and transmoding
- Content summarization and personalization strategies
- End-to-end quality of service support for Universal Multimedia Access
- Semantic mapping and ontologies
- Multimedia analysis for new and emerging applications
- Multimedia analysis hardware and middleware
- Semantic web and social networks
- Advanced interfaces for content analysis and relevance feedback
- Applications

Paper Submission
All submissions will be handled electronically. Submission instructions are posted on the workshop website (http://www.wiamis2010.org). The authors are requested to send their original submissions, 4 pages, double column in English. All submissions will be peer reviewed by at least three members of the technical program committee.
The conference proceedings will be available in IEEExplore.
An extended version of selected papers will be published in the Springer's Lecture Notes in Computer Science Series.

WIAMIS 2010 schedule	
Proposal of Special Sessions:	October 30, 2009
Conditional Acceptance of Special Sessions:	November 10, 2009
Paper Submission:	November 20, 2009
Special Session Paper Submission:	November 30, 2009
Notification of Acceptance:	January 15, 2010
Camera–ready Papers:	February 15, 2010

General Chairman
B. Boashash
Qatar University & University of Qld, Aust

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Universiti Teknologi Malaysia

Conference Vice-Chair
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Universiti Teknologi Malaysia

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Ecole Nationale Polytechnique, Algeria

Thierry Chonavel
Telecom Bretagne, France

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King Fahd University of Petroleum & Minerals, KSA

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University de Poitiers, France

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Eko Supriyanto
Universiti Teknologi Malaysia

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Jeong Jiansoo
Universiti Teknologi Malaysia

Registration
Nasir Shaikh Husain
Universiti Teknologi Malaysia

Local Arrangements
Rosbi Mamat
Universiti Teknologi Malaysia

IEEE Liaison
Malaysia: Mohd Faizal
Multimedia University, Malaysia

Exhibition
Mohd Yusof Mashor
Universiti Malaysia Perlis

Social Events
Raveendran Paramesran
Universiti Malaya, Malaysia

Web and IT
Kumutha Muruyandy
SPACE, Universiti Teknologi Malaysia

Final Call for Papers

ISSPA 2010 is the tenth event in the series of conferences, which since 1985 has brought together leading researchers and practitioners from academia and industry engaged in research and development related to signal processing theory and applications. In 2007, ISSPA extended its coverage to include the complementary field of Information Sciences.

ISSPA 2010 is co-organized by the Faculty of Biomedical & Health Science Engineering and Faculty of Electrical Engineering, Universiti Teknologi Malaysia(UTM) in cooperation with University Malaya (UM), Universiti Malaysia Perlis(UniMAP), MIMOS Berhad and with the support of several other bodies and international universities around the world including the University of Queensland, Australia, University Paris tech(ENST), University of Paris 12&13, Qatar university and KFUPM, KSA.

The regular technical program will run for three days along with an exhibition of signal processing products and research. In addition, a number of tutorial sessions will be scheduled one day before the conference starts.

Prospective authors are invited to submit full length (four pages) papers via the conference website for presentation in any of the areas listed below. We also encourage the submission of proposals for tutorial sessions on the related topics. All submitted papers will be subjected to a blind peer-review process.

1. Theory & Methods
2. Multirate Filtering & Wavelets
3. Adaptive Signal Processing
4. Time-Frequency/Time-Scale Analysis
5. Statistical Signal & Array Processing
6. Radar & Sonar Processing
7. Speech Processing & Recognition
8. Soft Computing & Pattern Recognition
9. Machine Learning
10. VLSI for Signal and Image Processing
11. Signal Processing for Bioinformatics
12. Biometrics Systems and Security
13. Fractals and Chaos Signal Processing
14. Image & Multidimensional Signal Processing
15. Signal Processing for Communications
16. Image and Video Processing
17. Visual Signal Processing
18. Biomedical Signal and Image Processing
19. Natural Language Processing
20. Nonlinear Signal Processing
21. Multimedia Signal Processing
22. Image Sequence Analysis & Processing
23. Photonic & Optical Signal Processing
24. Signal Processing in Networking
25. Signal Processing for Geo-informatics
26. Sensor Networks and Sensor Fusion
27. Data Mining
28. Special Sessions and Others (please specify area)

All accepted papers will be included in the ISSPA 2010 Conference Proceedings. All papers accepted will be included in IEEE Xplore. For more details, please visit our website:

www.isspa2010.com

Important Deadlines:

Full paper Submission: 20th November 2009
Tutorials & Special Sessions Submission: 25th November 2009
Notification of Acceptance: 15th February 2010
Camera Ready Paper: 1st March 2010

International Liaisons

Middle East: Braham Barkat
Petroleum Institute, UAE

Africa: Mohamed Siala
Sup' Com, Tunisia

America: Surya Santoso
University of Texas

Europe: Nathan Stevenson
Cork University, Ireland

Australasia: John O'Toole
University of Qld, Aust

Conference Secretariat

Faculty of Biomedical & Health Science Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor Darul Takzim, Malaysia.
Phone: +607 5536221 Fax: +607 5535430 email: secretariat@isspa2010.com/info@isspa2010.com

CIP2010

The second IAPR international workshop on

Cognitive Information Processing

14-15-16 June 2010, Elba Island, Italy

In cooperation with EURASIP, IET, IEEE-AESS, and IEEE-SP

CALL FOR PAPERS

Following the success of the first edition of the workshop on *Cognitive Information Processing* (CIP), we are pleased to announce the second one in this series. This workshop aims at bringing together researchers from the machine learning, pattern recognition, statistical signal processing, communications and radar communities in an effort to promote and encourage cross-fertilization of ideas and tools.

CIP2010 will take place in Italy, in the beautiful Tuscan island of Elba, at the **Grand Hotel Elba International** (*www.elbainternational.it*), which dominates the Bay of Naregno.

The workshop will feature keynote addresses and technical presentations, oral and poster, all of which will be included in the workshop proceedings.

Papers are solicited for the following areas in theory and applications:

THEORY:

- Learning theory and modelling
- Bayesian learning and models
- Information theoretic learning
- Graphical and kernel methods
- Adaptive learning algorithms
- Ensembles: committees, mixtures, boosting, etc.
- Data representation and analysis
- Collaborative sensing techniques
- Other topics for cognitive information processing

APPLICATIONS:

- Cognitive radio networks
- Cognitive radio modulation techniques
- Dynamic spectrum management
- Opportunistic resource allocation
- Cognitive radar and sonar
- Knowledge based target detection, estimation, tracking and identification
- Waveform agility design
- Blind source separation
- Cognitive dynamic systems
- Distributed, cooperative and adaptive processing
- Remote sensing

KEYNOTE SPEAKERS

Christopher Bishop (Microsoft Research Cambridge, UK)
Nello Cristianini (University of Bristol, UK)
Alfonso Farina (SELEX-SI, Italy)
Georgios B. Giannakis (University of Minnesota, USA)
Marco Luise (University of Pisa, Italy)
Joseph Mitola (Stevens Institute of Technology, USA)

IMPORTANT DATES

Full four-page paper submission:
January 10, 2010
Notification of acceptance:
March 10, 2010
Final camera-ready papers and author registration:
April 10, 2010

General Co-Chairs
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Sergios Theodoridis, Univ. of Athens, Greece
stheodor@di.uoa.gr

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For more information visit the website at: *www.conference.iet.unipi.it/cip2010*

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SPAWC 2010, the eleventh IEEE International Workshop on Signal Processing Advances for Wireless Communications is devoted to recent advances in signal processing for wireless and mobile communications.

This workshop brings together members of the signal processing, communications, information and network theory communities, working in universities, government and industrial research centers. The meeting will feature keynote addresses by leading researchers, as well as invited and contributed papers. SPAWC 2010 will be held from June 20, 2010 to June 23, 2010 in Marrakech, Morocco.

Conference URL: http://www.spawc2010.org

Paper Submission

Prospective authors are invited to submit papers in the following areas:

- Smart antennas, MIMO systems, and space-time coding
- Single-carrier, multi-carrier, and multi-rate systems
- Multiple access and broadcast channels, multi-user receivers
- Fundamental limits on capacity and performance analysis
- Cross-layer issues: from physical to networking and application layers
- Signal processing tools for ad hoc, multi-hop, and sensor networks
- Cooperative transmission and reception schemes
- Cognitive networking
- Distributed resource allocation and scheduling
- Ultra-wideband radio and RFID
- Time, frequency, spatial, multi-user diversity in fading channels
- Modeling, estimation and equalization of time-varying channels
- Acquisition, synchronization, and tracking (data aided or blind)
- Signal separation, and interference rejection
- Spread-spectrum systems
- Source-channel coding
- Low-complexity implementations
- Novel communication modalities

Important Dates

Submission deadline: February 1, 2010

Notification of acceptance: March 30, 2010

Final paper due: April 10, 2010

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Call For Papers

Following the seven successful previous events of CBMI (Toulouse 1999, Brescia 2001, Rennes 2003, Riga 2005, Bordeaux 2007, London 2008 and Chania 2009), the Laboratoire d'Informatique de Grenoble will organize the next CBMI event. CBMI 2010 aims at bringing together the various communities involved in the different aspects of Content-Based Multimedia Indexing. The scientific program of CBMI 2010 will include the presentation of invited plenary talks, special sessions as well as regular sessions with contributed research papers.

Topics of interest include, but are not limited to:

- Multimedia indexing and retrieval (image, audio, video, text)
- Matching and similarity search
- Construction of high level indices
- Multimedia index extraction
- Identification and tracking of semantic regions in scenes
- Multi-modal and cross-modal indexing
- Content-based search
- Multimedia data mining
- Metadata generation, coding and transformation
- Large scale multimedia database management
- Summarization, browsing and organization of multimedia content
- Presentation and visualization tools
- User interaction and relevance feedback
- Personalization and content adaptation
- Evaluation and metrics

Paper submission

Authors are invited to submit full papers at the conference web site www.cbmi2010.org. Style files (Latex and MS Word) will be provided.

Important Dates

Submission of full papers	January 7, 2010
Notification of acceptance	February 26, 2010
Submission of camera-ready papers	March 12, 2010
Early registration until	June 1, 2010
Main workshop	June 23-25, 2010

Venue

CBMI 2010 will be hosted by the LIG, Grenoble, France.

www.cbmi2010.org

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Fourth International Conference on Image and Signal Processing

ICISP 2010

June 30 - July 2, Trois-Rivières, Québec, Canada

CALL FOR PAPERS

Following the two successful previous editions of ICISP (Agadir 2001, Agadir 2003, Cherbourg 2008), the *Université du Québec à Trois-Rivières* will organize the next ICISP event. ICISP aims to provide researchers and practitioners from academia and industry with a forum on the last developments in image and signal processing, multimedia and computer graphics. The conference will also provide a unique opportunity for sharing experiences from different backgrounds with the common interest in advanced methods in the above-mentioned fields. The scientific program of ICISP 2010 will include the presentation of invited plenary talks, poster and regular sessions with contributed research papers.

Best papers will be published in a special issue of the International Journal of Future Generation Communication and Networking IJFGCN
http://www.sersc.org/journals/IJFGCN

Topics of interest for submission include, but are not limited to:

- Image and video processing: image filtering, restoration and enhancement, image segmentation, video segmentation and tracking, morphological processing, feature extraction and analysis, interpolation and super-resolution, motion detection and estimation, computer vision, pattern recognition, content-based image retrieval.
- Signal Processing: spectral analysis, time-frequency and time-scale representation, statistical signal processing, filtering, detection and estimation, nonlinear signal processing, radar, antennas, telecommunications systems, acoustics.
- Computer graphics: algorithms, visualization, animation, virtual reality.
- Applications: biomedical sciences, biometry, document image processing and authentication, other applications.

PAPER SUBMISSION

Prospective authors are invited to submit full papers of not more than eight (8) pages including results, figures and references. All the papers will be handled and reviewed electronically through the conference web site.

Submission of full paper	**January 22, 2010**
Notification of acceptance	**March 12, 2010**
Submissions of camera-ready papers	**April 12, 2010**

CONFERENCE VENUE

ICISP'2010 will be held in Trois-Rivières, Québec, Canada from June 30 to July 2, 2010.

For further information: http://www.uqtr.ca/icisp

Université de Caen Basse-Normandie

Université du Québec à Trois-Rivières

IPTA 2010 International Conference on Image Processing Theory, Tools & Applications

http://ipta10.ibisc.univ-evry.fr

July 7-10, 2010, Paris – France

Call For Papers

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The second edition of the international Conference on Image Processing Theory, Tools and Applications IPTA'10 aims at gathering challenging international researchers, innovators, educators, and practitioners in image processing theory and tools, for attending extensive educational high level materials, sharing their achievements, exchanging their experiences and discussing future orientations. The conference will also offer an opportunity to fill the gap between image processing researchers and people working in other application fields such as doctors, radiotherapists and industrial parts. Closer link will be focused on between image processing algorithms and the way to implement these algorithms for best performances. To address these challenges and explore these new opportunities, the conference aims to provide an excellent forum for all experts in these areas to meet and discuss various important issues on image processing and applications. Four areas compose the conference topics:

1: Image acquisition, coding and compression tools
- Images acquisition systems and information extraction,
- Algorithm-architecture adequacy in image processing
- Images processing tools
- Images coding and compression
- Geometrical Compression of 3D data,
- Watermarking

2: Image processing and computer vision:
- Image filtering and restoration,
- Image segmentation and detection,
- Image modeling,
- Estimation, representation and image analysis,
- Multivariate image processing
- Shapes analysis and pattern recognition,
- Tracking and dynamical analysis,
- Geometrical image description,
- Features extraction and description,
- Image interpretation and recognition,
- Statistical Learning methods for images classification,
- Complex systems for images analysis.

3: Virtual and augmented reality, visualization and interaction:
- Software architecture for VR and AR system
- Real time modelling and animating virtual environments
- Multimodal rendering (visual, haptic,...)
- 3D interaction techniques and user assistance
- Interaction based on tangible interface
- 3D tracking based on hybrid sensors (vision, inertial, GPS,...)

4: Applications:
- Content based image retrieval systems,
- Biological and medical imaging,
- Image processing for biological systems,
- Visual information processing,
- Biometric authentication, face and iris recognition,
- Robotics applications,
- Diagnosis optimization methods,
- Medical imaging systems technology,
- Classification tools for image-based diagnosis,
- Vision systems

PAPER SUBMISSION

Papers describing general surveys, image processing fundamental theory, specific image processing applications, advanced prototypes, tools and methodologies are welcomed. Extended papers describing original contributions are encouraged in the conference topics mentioned above. Accepted papers, presented at the conference by one of the authors, are subject of selection for international journals.

Special Sessions Proposal:	**December**	**15th**	**2009**
Special Sessions notification:	**January**	**3rd**	**2010**
Tutorials Proposal:	**February**	**15th**	**2010**
Tutorials notification:	**February**	**28th**	**2010**
Regular paper submissions:	**March**	**1st**	**2010**
Regular paper notification:	**April**	**3rd**	**2010**
Final Paper Submission and Registration:	**April**	**15th**	**2010**

SPECIAL SESSIONS

Special Sessions proposals should be submitted by December 15, 2009. Proposals for special sessions must include a topical title, rationale, session outline, contact information for the session chair(s), a list of authors who have agreed to present a paper in the session, and a tentative title and abstract of each paper.

TUTORIALS

Tutorials will be held on the first day of the conference. Proposal for tutorials must include a title, an outline of the tutorial and its motivation, a two-page CV of the presenter(s), and a short description of the material to be covered.

For further information, the contact secretariat is at: **iptta@ibisc.univ-evry.fr**

7th *IEEE, IET International Symposium on*

COMMUNICATION SYSTEMS, NETWORKS & DIGITAL SIGNAL PROCESSING (*CSNDSP'10*)

21-23 July 2010, Northumbria University at Newcastle, U.K

Hosted by: School of Computing, Engineering and Information Sciences

www.csndsp.com, First Call for Papers

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IEEE Communications Chapter - UKRI

IEEE Signal Processing Society - UKRI Chapter

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CSNDSP has now been recognised as a forum for the exchange of ideas among engineers, scientists and young researchers from all over the world on advances in communication systems, communications networks, digital signal processing and other related areas and to provide a focus for future research and developments. The organising committee invites you to submit original high quality papers addressing research topics of interest for presentation at the 7th symposium which be held in the beautiful city of Newcastle in U.K. For the second time we also have dedicated colloquiums and number of special sessions on selected topics.

- **Colloquiums on**
  - ***Photonic Communications Systems and Networks***
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Papers are solicited from, but not limited to the following topics:

- Ad-Hoc networks
- Adaptive signal processing
- ATM systems and networks
- Chip design for Communications
- Communication theory
- Coding and error control
- Communication protocols
- Communications for disaster management
- Crosslayer design
- Digital and multirate signal processing
- DSP algorithms and applications
- E-commerce and e-learning applications
- Implementation of signal processing and communications systems
- Intelligent systems/networks
- Internet communications
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- Mobile communications, networks, mobile computing for e-commerce
- Mobility management
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- Modelling and simulation techniques
- Multidimensional signal processing
- Multimedia communications and broadband services
- Nano-technology in communications
- New techniques in RF-design and modelling
- Network management & operation
- Optical communications
- Optical MEMS for lightwave networks
- RF/optical wireless communications
- Photonic network
- Quality of service, reliability and performance modelling
- 3G/4G network evolution
- Radio, satellite and space communications
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- Sensor networks
- Signal processing for communications and sensor networks
- Signal processing for storage
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- Papers may be presented in the form of **Oral presentation and/or Poster**
- Contributions by **MPhil/PhD** research **students** are particularly encouraged.

Submission Dates:

• **Full Paper due:**	**3rd Feb. 2010**
• Notification of acceptance by:	1st April 2010
• Camera ready paper due:	5th May 2010

- Submission is ONLY possible via the website http://www.csndsp.com. For more information please visit the website or contact the Local Committee via email csndsp10@norhumbria.ac.uk

All papers will be reviewed by at least three referees. Only papers presented at the conference will be available in the IEEE-Xplore, once it is confirmed by the IEEE. More information to follow on this.

Selected best papers presented will be published in the special issue of selected journals.

- **Once again CSNDSP will offer a number of travel grants and registration fee waivers**.

Fees:

£300.0/person (2 papers), £550.0 for two persons (4 papers), £750.0 for 3 persons (6 papers)

It includes: ***A copy of the Symposium Proceedings, Lunches, Lord Mayer's Reception on 21 July, Day trip to the Cragside on 23 July, Symposium Dinner at Hilton Hotel on 22 July 2010.***

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Contact: Professor Z Ghassemlooy - *Local Organising Committee Chair:* School of CEIS, Northumbria University, Newcastle upon Tyne, NE1 8ST, U.K., Tel.: ++44 191 227 4902, Fax.: ++44 191 227 3684.
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2nd European Workshop on Visual Information Processing – EUVIP 2010

July 5th - 6th, 2010

Université Paris 13, Paris, France

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First Call For Papers

The extensive use of digital visual media in our everyday life and their inherent presence around us; urges for the development of smarter and more efficient approaches for modeling, analyzing, processing and communication of visual information. Machine vision techniques have gone so far and are able to perform tasks that one could only dream of a few years ago; thanks to smarter algorithms, large increase in processing power, storage capabilities and communication bandwidth available in today's computers and networks. Nevertheless, they fall short of our expecting when compared to the ease with which the human visual system (HVS) deals with complex scenes analysis, processing and abstraction. Therefore, we are witnessing a growing interest in approaches inspired from the HVS for digital visual information modeling, analysis, processing and communication.

To cover recent advances in these approaches EUVIP 2010, tries to bring together prominent experts to exchange ideas and explore the frontiers of this research field.

This is the second instance of the workshop which follows up on the success achieved by the first one (called VISPA 2008). The first workshop attracted prominent speakers from around the world and provided a platform for fruitful discussions on different applications of signal and image processing techniques to emerging and challenging problems. Carrying on this tradition EUVIP 2010, will offer a forum for researchers and industrialists to exchange ideas and discuss the recent advances in Human Visual System (HVS) inspired techniques for image and video processing with applications to multimedia, visual pattern recognition, surveillance, and visual information security. It will be organized as a series of invited pedagogical talks, and technical papers presentations dealing with state of the art visual information modeling, analysis, processing and communication methods. The workshop aims to promote exchanges between established researchers as well as to provide graduate students with an opportunity to have substantive interaction with experts in the field.

Topics of particular interest to EUVIP 2010 include, but are not limited to:

Computational Vision Models	Video Analysis
Image and Video Quality Assessment	Visual Tracking
Image and Video Enhancement	Visual Data Mining
Color Image Understanding	Biometrics
Color Image Processing	Perceptual Digital Watermarking
Perceptual Image & Video Retrieval	Perceptual coding
Multimedia Communication	Multiview Processing

Submission

Perspective authors are invited to submit full length (four pages) papers at www.euvip2010.org (*to be updated*). Formatted according to the guidelines in the author guide.

Important dates

Submission Deadline: 15 February 2010
Notification of acceptance: 15 March 2010
Camera Ready Deadline: 15 April 2010

Temporary website: http://www-l2ti.univ-paris13.fr/~euvip/index.htm

For additional information, send your request to: euvip@univ-paris13.fr

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CALL FOR PAPERS

2010 European Signal Processing Conference (EUSIPCO-2010), August 23-27 2010, Aalborg, Denmark

The 2010 European Signal Processing Conference (EUSIPCO-2010) is the 18th of its kind organized by the European Association for Signal, Speech, and Image Processing (EURASIP). The conference will be held at Aalborg Congress & Culture Centre in Aalborg, Denmark and is organized by Aalborg University. The focus will be on signal processing theory, algorithms, and applications. Papers will be accepted based on quality, relevance, and novelty and accepted papers will be published in the proceedings of EUSIPCO-2010 as well as presented at the conference.

Areas of Interest

Submissions are invited in, but not limited to, the following areas:

* Audio and electroacoustics
* Design and implementation of signal processing systems
* Multimedia signal processing
* Speech processing
* Image and video processing
* Signal estimation and detection
* Sensor array and multi-channel processing
* Signal processing for communications
* Nonlinear signal processing
* Signal processing applications

Submission

Procedures to submit a paper, proposal for special sessions and tutorials are detailed at www.eusipco2010.org. Submitted papers must be camera-ready, no more than five pages long, and conforming to the format specified on the EUSIPCO-2010 website.

Important Dates

* Proposals for special sessions December 4, 2009
* Proposals for tutorials February 5, 2010
* Electronic submission of papers February 5, 2010
* Notification of acceptance April 30, 2010
* Submissions of camera-ready papers May 28, 2010

www.eusipco2010.org

EURASIP

Preliminary call for papers

The 2011 European Signal Processing Conference (EUSIPCO-2011) is the nineteenth in a series of conferences promoted by the European Association for Signal Processing (EURASIP, www.eurasip.org). This year edition will take place in Barcelona, capital city of Catalonia (Spain), and will be jointly organized by the Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) and the Universitat Politècnica de Catalunya (UPC).

EUSIPCO-2011 will focus on key aspects of signal processing theory and applications as listed below. Acceptance of submissions will be based on quality, relevance and originality. Accepted papers will be published in the EUSIPCO proceedings and presented during the conference. Paper submissions, proposals for tutorials and proposals for special sessions are invited in, but not limited to, the following areas of interest.

Areas of Interest

- Audio and electro-acoustics.
- Design, implementation, and applications of signal processing systems.
- Multimedia signal processing and coding.
- Image and multidimensional signal processing.
- Signal detection and estimation.
- Sensor array and multi-channel signal processing.
- Sensor fusion in networked systems.
- Signal processing for communications.
- Medical imaging and image analysis.
- Non-stationary, non-linear and non-Gaussian signal processing.

Submissions

Procedures to submit a paper and proposals for special sessions and tutorials will be detailed at www.eusipco2011.org. Submitted papers must be camera-ready, no more than 5 pages long, and conforming to the standard specified on the EUSIPCO 2011 web site. First authors who are registered students can participate in the best student paper competition.

Important Deadlines:

Proposals for special sessions
Proposals for tutorials
Electronic submission of full papers
Notification of acceptance
Submission of camera-ready papers

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Webpage: www.eusipco2011.org

The Third International EURASIP Workshop on RFID Technology

RFID 2010

6-7 September 2010, La Manga del Mar Menor, Cartagena, Spain

Call for Papers

The third international EURASIP workshop on RFID technology will provide a premium forum for presentation of the most recent research in this new technology. The objective is to continue, accelerate, and broaden the momentum already gained in this field. This call for papers intends to solicit contributions on the latest research of this new technology for wireless communication systems, spanning from the individual tag to entire systems based on RFIDs.

Important Dates

Paper submission: 25. May 2010
Author notification: 29. June 2010
Final version due: 14. July 2010
Conference: 6-7 September 2010

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The topics of the conference include, but are not limited to:

- Electromagnetic field measurements
- Antenna Design
- Multiple antenna systems
- Modulation schemes for RFID
- Link, system and network level simulations
- Hardware and software implementation issues
- Inductive coupling for DC supply
- Multi-frequency and broadband tags
- Near field communications
- Smart tags, programmable tags and embedded systems
- Sensor tags and RFID for asset tracking and localization
- Advances in passive long range RFID technology
- Manufacturing processes for RFID tags
- Applications and industrial experience
- Standards and communication protocols
- Internet of things

Submissions guidelines:

Authors are encouraged to submit original, unpublished work for presentation at the workshop in the form of posters and/or full papers. Acceptance shall be based on an extended abstract of at most four pages or (if already avaliable) on full papers.
More information: http://www.ait.upct.es/EURASIP-RFID2010/

Workshop Venue:

The workshop will be held in **La Manga del Mar Menor**, Cartagena, Spain.

Award Winning Papers by EURASIP

EURASIP is presently running ten scientific Journals (three with Elsevier and seven with Hindawi) and concomitantly we give awards to distinguish excellent papers. The award process is run by a separate committee for each Journal, appointed by the AdCom of EURASIP. Depending on the submission numbers, awards are given annually or biannually. EURASIP has witnessed over the years the truly excellent quality of papers submitted to our Journals, and we would like to take the opportunity to celebrate those award winning papers for our members.

The paper we present in this newsletter issue is the award winning paper 2008 of our EURASIP Journal on Wireless Communications and Networking (JWCN) entitled:

On-Off Frequency-Shift Keying for Wideband Fading Channels

Mustafa Cenk Gursoy, H. Vincent Poor, and Sergio Verdú

Volume 2006 (2006), Article ID 98564, 15 pages, doi:10.1155/WCN/2006/98564

Markus Rupp
President

Hindawi Publishing Corporation
EURASIP Journal on Wireless Communications and Networking
Volume 2006, Article ID 98564, Pages 1–15
DOI 10.1155/WCN/2006/98564

On-Off Frequency-Shift Keying for Wideband Fading Channels

Mustafa Cenk Gursoy,[1,2] H. Vincent Poor,[1] and Sergio Verdú[1]

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Received 9 March 2005; Revised 20 August 2005; Accepted 15 September 2005

Recommended for Publication by Richard Kozick

M-ary on-off frequency-shift keying (OOFSK) is a digital modulation format in which M-ary FSK signaling is overlaid on on/off keying. This paper investigates the potential of this modulation format in the context of wideband fading channels. First, it is assumed that the receiver uses energy detection for the reception of OOFSK signals. Capacity expressions are obtained for the cases in which the receiver has perfect and imperfect fading side information. Power efficiency is investigated when the transmitter is subject to a peak-to-average power ratio (PAR) limitation or a peak power limitation. It is shown that under a PAR limitation, it is extremely power inefficient to operate in the very-low-SNR regime. On the other hand, if there is only a peak power limitation, it is demonstrated that power efficiency improves as one operates with smaller SNR and vanishing duty factor. Also studied are the capacity improvements that accrue when the receiver can track phase shifts in the channel or if the received signal has a specular component. To take advantage of those features, the phase of the modulation is also allowed to carry information.

1. INTRODUCTION

A wide range of digital communication systems in wireless, deep space, and sensor networks operate in the low-power regime where power consumption rather than bandwidth is the limiting factor. For such systems, power-efficient transmission schemes are required for effective use of scarce energy resources. For example, in sensor networks [1], nodes that are densely deployed in a region may be equipped with only a limited power source and in some cases replenishment of these resources may not be possible. Therefore, energy-efficient operation is vital in these systems. Recently, there has also been much interest in ultra-wideband systems in which low-power pulses of very short duration are used for communication over short distances. These wideband pulses must satisfy strict peak power requirements in order not to interfere with existing systems.

The power efficiency of a communication system can be measured by the energy required for reliable communication of one bit. When communicating at rate R bps with power P, the transmitted energy per bit is $E_b = P/R$. Since the maximum rate is given by the channel capacity, C, the least amount of bit energy required for reliable communication is $E_b = P/C$. In [2], Shannon showed that the capacity of an ideal bandlimited additive white Gaussian noise channel is $C = B\log_2(1 + P/BN_0)$ bps, where P is the received power, B is the channel bandwidth, and N_0 is the one-sided noise spectral level. As the bandwidth grows to infinity, the capacity monotonically increases to $(P/N_0)\log_2 e$ bps, therefore decreasing the required received bit energy normalized to the noise power to

$$\frac{E_b^r}{N_0} = \frac{P/N_0}{C} \underset{B\to\infty}{\longrightarrow} \log_e 2 = -1.59\,\text{dB}. \tag{1}$$

This minimum bit energy (1) can be approached by pulse-position modulation with vanishing duty cycle [3] or by M-ary orthogonal signaling as M becomes large [4]. In the presence of unknown fading, Jacobs [5] and Pierce [6] have noted that M-ary orthogonal signaling obtained by frequency-shift keying (FSK) modulation can still approach the limit in (1) for large values of M. Gallager [7, Section 8.6] also demonstrated that over fading channels M-ary orthogonal FSK signaling with vanishing duty cycle approaches the infinite bandwidth capacity of unfaded Gaussian channels as $M \to \infty$, thereby achieving (1). The result that the infinite bandwidth capacity of fading channels is the same as that of unfaded Gaussian channels is also noted by Kennedy [8]. Telatar and Tse [9] considered a more general fading channel model that consists of a finite number of time-varying paths and showed that the infinite bandwidth capacity of this channel is again approached by using peaky FSK signaling. Luo

and Médard [10] have shown that FSK with small duty cycle can achieve rates of the order of capacity in ultrawideband systems with limits on bandwidth and peak power. Reference [11] shows, in wider generality than was previously known, that the minimum received bit energy normalized to the noise level in a Gaussian channel is -1.59 dB, regardless of the knowledge of the fading at the receiver and/or transmitter. It is also shown in [11] that if the receiver does not have perfect knowledge of the fading, flash signaling is required to achieve the minimum bit energy. The performance degradation in the wideband regime incurred by using signals with limited peakedness is discussed in [9, 12, 13]. The error performance of FSK signals used with a duty cycle is analyzed in [14, 15].

Besides approaching the minimum energy per bit, FSK modulation is particularly suitable for noncoherent communications. Butman et al.[16] studied the performance of M-ary FSK, which has unit peak-to-average power ratio, over noncoherent Gaussian channels by computing the capacity and computational cutoff rate. Stark [17] analyzed the capacity and cutoff rate of M-ary FSK signaling with both hard and soft decisions in the presence of Rician fading and noted that there exists an optimal code rate for which the required bit energy is minimized.

In this paper, we study the power efficiency of M-ary on/off FSK (OOFSK) signaling in which M-ary FSK signaling is overlaid on top of on/off keying, enabling us to introduce peakedness in both time and frequency. Our main focus will be on cases in which the peakedness of input signals is limited. The organization of the paper is as follows. Section 2 introduces the channel model. In Section 3, we find the capacity of M-ary orthogonal OOFSK signaling with energy detection at the receiver and investigate the power efficiency in two cases: limited peak-to-average power ratio and limited peak power. In Section 4, we consider joint frequency and phase modulation and analyze the capacity and power efficiency of M-ary OOFPSK signaling in which the phase of FSK signals also convey information. Finally, Section 5 includes our conclusions.

2. CHANNEL MODEL

In this section, we present the system model. We assume that M-ary orthogonal OOFSK signaling, in which FSK signaling is combined with on/off keying with a fixed duty factor, $\nu \leq 1$, is employed at the transmitter for communication over a fading channel. In this signaling scheme, over the time interval of $[0, T]$, the transmitter either sends no signal with probability $1-\nu$ or sends one of M orthogonal sinusoidal signals,

$$s_i(t) = \sqrt{\frac{P}{\nu}} e^{j(\omega_i t + \theta_i)}, \quad 0 \leq t \leq T,\ 1 \leq i \leq M, \tag{2}$$

with probability ν. To ensure orthogonality, adjacent frequency slots satisfy $|\omega_{i+1} - \omega_i| = 2\pi/T$. Choosing $\nu = 1$, we obtain ordinary FSK signaling. If the channel input is $X = i$ for $1 \leq i \leq M$, the transmitter sends the sine wave $s_i(t)$, while no transmission is denoted by $X = 0$. Note that OOFSK signaling has average power P, and peak power P/ν. We assume that the transmitted signal undergoes stationary and ergodic fading and that the delay spread of the fading is much less than the symbol duration. Under these assumptions, the fading has a multiplicative effect on the transmitted signal and the received signal can be modeled as follows:

$$\begin{aligned} r(t) &= h(t) s_{X_k}(t-(k-1)T) + n(t), \\ (k-1)T &\leq t \leq kT, \quad \text{for } k = 1, 2, \ldots, \end{aligned} \tag{3}$$

where $\{X_k\}_{k=1}^{\infty}$ is the input sequence with $X_k \in \{0, 1, 2, \ldots, M\}$, $h(t)$ is a proper[1] complex stationary ergodic fading process with $E\{h(t)\} = d$ and $\mathrm{var}(h(t)) = \gamma^2$, and $n(t)$ is a zero-mean circularly symmetric complex white Gaussian noise process with single-sided spectral density N_0. Note that $s_0(t) = 0$. If we further assume that the symbol duration T is less than the coherence time of the fading, then the fading stays constant over the symbol duration and the channel model now becomes

$$r(t) = h_k s_{X_k}(t-(k-1)T) + n(t), \quad (k-1)T \leq t \leq kT. \tag{4}$$

At the receiver, a bank of correlators is employed in each symbol interval to obtain the M-dimensional vector $\mathbf{Y}_k = (Y_{k,1}, \ldots, Y_{k,M})$, where

$$Y_{k,i} = \frac{1}{\sqrt{N_0 T}} \int_{(k-1)T}^{kT} r(t) e^{-j\omega_i t}\, \mathrm{d}t, \quad i = 1, 2, \ldots, M. \tag{5}$$

It is easily seen that, given the symbol $X_k = i$, phase θ_i and fading coefficient h_k, $Y_{k,j}$ is a proper complex Gaussian random variable with

$$\begin{aligned} E\{Y_{k,j} \mid X_k = i, \theta_i, h_k\} &= \alpha h_k e^{j\theta_i} \delta_{ij}, \\ \mathrm{var}\left(Y_{k,j} \mid X_k = i, \theta_i, h_k\right) &= 1, \end{aligned} \tag{6}$$

where $\delta_{ij} = 1$ if $i = j$ and is zero otherwise, and $\alpha^2 = PT/\nu N_0 = \mathrm{SNR}/\nu$ with SNR denoting the signal-to-noise ratio per symbol.

3. CAPACITY OF M-ARY ORTHOGONAL OOFSK SIGNALING WITH ENERGY DETECTION

In this section, we analyze the capacity of M-ary orthogonal OOFSK signaling when in every symbol interval, the noncoherent receiver measures the energy at each of the M frequencies, that is, computes

$$\begin{aligned} R_{k,i} = \left| Y_{k,i} \right|^2 = \left| \frac{1}{\sqrt{N_0 T}} \int_{(k-1)T}^{kT} r(t) e^{-j\omega_i t}\, \mathrm{d}t \right|^2, \\ 1 \leq i \leq M, \quad \text{for } k = 1, 2, \ldots, \end{aligned} \tag{7}$$

and the decoder sees the vector $\mathbf{R}_k = (R_{k,1}, \ldots, R_{k,M})$. With this structure, the receiver does not need to track phase

[1] See [18].

changes in the channel. We consider the cases where the receiver has either perfect or imperfect fading side information, while the transmitter has no knowledge of the fading coefficients. Besides providing the ultimate limits on the rate of communication, capacity results also offer insight into the power efficiency of OOFSK signaling by enabling us to obtain the energy required to send one bit of information reliably.

In the low-power regime, the spectral-efficiency/bit-energy tradeoff reflects the fundamental tradeoff between bandwidth and power. Assuming that the bandwidth of M-ary OOFSK modulation is M/T, where T is the symbol duration, the maximum achievable spectral efficiency is

$$\mathrm{C}\left(\frac{E_b}{N_0}\right) = \frac{1}{M}C(\mathrm{SNR})\ \text{bps/Hz}, \tag{8}$$

where $C(\mathrm{SNR})$ is the capacity in bits/symbol, and

$$\frac{E_b}{N_0} = \frac{\mathrm{SNR}}{C(\mathrm{SNR})} \tag{9}$$

is the bit energy normalized to the noise power. For average-power-limited channels, the bit energy required for reliable communications decreases monotonically with decreasing spectral efficiency, and the minimum bit energy is achieved at zero spectral efficiency, that is, $E_b/N_{0\min} = \lim_{\mathrm{SNR}\to 0}(\mathrm{SNR}/C(\mathrm{SNR})) = \log_e 2/\dot{C}(0)$, where $\dot{C}(0)$ is the first derivative of the capacity in nats. Hence, for fixed rate transmission, reduction in the required power comes only at the expense of increased bandwidth. Reference [11] analyzes the spectral-efficiency/bit-energy function in the low-power regime for a general class of average-power-limited fading channels and shows that the minimum bit energy is $\log_e 2 = -1.59$ dB as long as the additive background noise is Gaussian. This minimum bit energy is achieved only in the asymptotic regime of infinite bandwidth. If one is willing to spend more power, then reliable communication over a finite bandwidth is possible. Hence, achieving the minimum bit energy is not a sufficient criterion for finite bandwidth analysis. The wideband slope [11], defined as the slope of the spectral efficiency curve $\mathrm{C}(E_b/N_0)$ in bps/Hz/3dB at zero spectral efficiency, is given by

$$\begin{aligned} S_0 &\stackrel{\text{def}}{=} \lim_{E_b/N_0 \downarrow E_b/N_0|_{\mathrm{C}=0}} \frac{\mathrm{C}(E_b/N_0)}{10\log_{10}(E_b/N_0) - 10\log_{10}(E_b/N_0)|_{\mathrm{C}=0}} \\ &\qquad \times 10\log_{10} 2 \\ &= \frac{1}{M}\frac{2(\dot{C}(0))^2}{-\ddot{C}(0)}, \end{aligned} \tag{10}$$

where $\dot{C}(0)$ and $\ddot{C}(0)$ denote the first and second derivatives of the capacity in nats. Note that differing from the original definition in [11], normalization by M is introduced in (10) due to the scaling in (8). The wideband slope closely approximates the growth of the spectral-efficiency curve in the power-limited regime and hence is a useful tool providing insightful results when bandwidth is a resource to be conserved.

3.1. Perfect receiver side information

We first assume that the receiver has perfect knowledge of the magnitude of the fading, $|h|$. For this case, the capacity as a function of $\mathrm{SNR} = PT/N_0$ of M-ary OOFSK signaling with energy detection is given by the following proposition. Throughout the paper, we denote the probability density function and distribution function of a random variable Z by p_Z and F_Z, respectively, with arguments omitted in equations in order to avoid cumbersome expressions.

Proposition 1. Consider the fading channel model (4) and assume that the receiver knows the magnitude but not the phase of the fading coefficients $\{h_k,\ k = 1,2,\ldots\}$. Further assume that the transmitter has no fading side information. Then the capacity of M-ary orthogonal OOFSK signaling with a fixed duty factor $\nu \le 1$ with energy detection is

$$\begin{aligned} C_M^p(\mathrm{SNR}) = E_{|h|}\Bigg\{&(1-\nu)\int p_{\mathbf{R}|X=0}\log\frac{p_{\mathbf{R}|X=0}}{p_{\mathbf{R}||h|}}\,\mathrm{d}\mathbf{R} \\ &+ \nu\int p_{\mathbf{R}|X=1,|h|}\log\frac{p_{\mathbf{R}|X=1,|h|}}{p_{\mathbf{R}||h|}}\,\mathrm{d}\mathbf{R}\Bigg\}, \end{aligned} \tag{11}$$

where

$$p_{\mathbf{R}||h|} = (1-\nu)p_{\mathbf{R}|X=0} + \frac{\nu}{M}\sum_{i=1}^{M} p_{\mathbf{R}|X=i,|h|}, \tag{12}$$

$$p_{\mathbf{R}|X=0} = e^{-\sum_{j=1}^{M} R_j}, \tag{13}$$

$$p_{\mathbf{R}|X=i,|h|} = e^{-\sum_{j=1}^{M} R_j} f(R_i, |h|, \mathrm{SNR}), \quad 1 \le i \le M, \tag{14}$$

$$f(R_i, |h|, \mathrm{SNR}) = \exp\left(-\frac{\mathrm{SNR}}{\nu}|h|^2\right) I_0\left(2\sqrt{\frac{\mathrm{SNR}}{\nu}|h|^2 R_i}\right). \tag{15}$$

For the proof, see Appendix A.

Formula (11) must be evaluated numerically, and computational complexity imposes a burden on numerical techniques for large M. Fortunately, a simpler expression is obtained in the limit $M \to \infty$.

Proposition 2. The capacity expression (11) for M-ary OOFSK signaling in the limit as $M \uparrow \infty$ becomes

$$C_\infty^p(\mathrm{SNR}) = D\left(p_{R|\tilde{x},|h|}\,\|\,p_{R|\tilde{x}=0,|h|}\,\middle|\,F_{|h|}F_{\tilde{x}}\right), \tag{16}$$

where

$$R = |y|^2 = |h\tilde{x} + n|^2, \tag{17}$$

$\tilde{x}$ is a two-mass-point discrete random variable with the following mass-point locations and probabilities,

$$\tilde{x} = \begin{cases} 0, & \text{with probability } 1-\nu, \\ \sqrt{\dfrac{\mathrm{SNR}}{\nu}}, & \text{with probability } \nu, \end{cases} \tag{18}$$

and n is zero-mean circularly symmetric complex Gaussian random variable with $E\{|n|^2\} = 1$. Therefore,

$$p_{R|\tilde{x},|h|} = e^{-R-\tilde{x}^2|h|^2} I_0\left(2\sqrt{\tilde{x}^2|h|^2 R}\right). \tag{19}$$

For the proof, see Appendix B.

3.2. Imperfect receiver side information

In this section, we assume that neither the receiver nor the transmitter has any side information about the fading. Unlike the previous section, here we consider a more special fading process: memoryless Rician fading where each of the i.i.d. h_k's is a proper complex Gaussian random variable with $E\{h_k\} = d$ and $\mathrm{var}(h_k) = \gamma^2$. Note that the unknown Rician fading channel can also be regarded as an imperfectly known fading channel where the specular component is the channel estimate and the fading component is the Gaussian-distributed error in the estimate. As argued in [19], the Bayesian least-squares estimation over the Rayleigh channel leads to such a channel model. However, we want to emphasize that no explicit channel estimation method is considered in this section.

The following result gives the maximum rate at which reliable communication is possible with OOFSK signaling using energy detection over the memoryless Rician fading channel. As noted in Section 1, the capacity of the special case of M-ary FSK signaling ($\nu = 1$) was previously obtained by Stark [17].

Proposition 3. Consider the fading channel (4), and assume that the fading process $\{h_k\}$ is a sequence of i.i.d. proper complex Gaussian random variables with $E\{h_k\} = d$ and $\mathrm{var}(h_k) = \gamma^2$, which are not known at either the receiver or the transmitter. Further, assume that energy detection is performed at the receiver. Then the capacity of M-ary orthogonal OOFSK signaling with fixed duty factor $\nu \le 1$ is given by

$$C_M^{ip}(\mathrm{SNR}) = (1-\nu)\int p_{\mathbf{R}|X=0}\log\frac{p_{\mathbf{R}|X=0}}{p_{\mathbf{R}}}\,\mathrm{d}\mathbf{R} + \nu\int p_{\mathbf{R}|X=1}\log\frac{p_{\mathbf{R}|X=1}}{p_{\mathbf{R}}}\,\mathrm{d}\mathbf{R}, \tag{20}$$

where

$$p_{\mathbf{R}} = (1-\nu)p_{\mathbf{R}|X=0} + \frac{\nu}{M}\sum_{i=1}^{M} p_{\mathbf{R}|X=i}, \tag{21}$$

$$p_{\mathbf{R}|X=0} = e^{-\sum_{j=1}^{M} R_j}, \tag{22}$$

$$p_{\mathbf{R}|X=i} = e^{-\sum_{j=1}^{M} R_j} f(R_i, \mathrm{SNR}), \quad 1 \le i \le M, \tag{23}$$

$$f(R_i, \mathrm{SNR}) = \frac{1}{\gamma^2\,\mathrm{SNR}/\nu + 1}\exp\left(\frac{\mathrm{SNR}/\nu(\gamma^2 R_i - |d|^2)}{\gamma^2\,\mathrm{SNR}/\nu + 1}\right) \times I_0\left(\frac{2\sqrt{\mathrm{SNR}/\nu|d|^2 R_i}}{\gamma^2\,\mathrm{SNR}/\nu + 1}\right). \tag{24}$$

Proof. With the memoryless assumption, the capacity of the M-ary OOFSK signaling can be formulated as the maximum mutual information between the channel input X_k and output vector $\mathbf{R}_k$ for any k. Thus, considering a generic symbol interval, and dropping the time index k, we have

$$C = \max_X I(X;\mathbf{R}) = \max_X (1-\nu)\int p_{\mathbf{R}|X=0}\log\frac{p_{\mathbf{R}|X=0}}{p_{\mathbf{R}}}\,\mathrm{d}\mathbf{R} + \sum_{i=1}^{M} P(X=i)\int p_{\mathbf{R}|X=i}\log\frac{p_{\mathbf{R}|X=i}}{p_{\mathbf{R}}}\,\mathrm{d}\mathbf{R}. \tag{25}$$

Similarly as in the proof of Proposition 1, due to the symmetry of the channel, an input distribution equiprobable over nonzero input values, that is, $P(X = i) = \nu/M$ for $1 \le i \le M$, where $P(X = 0) = 1 - \nu$ achieves the capacity, and we easily obtain (20) by noting that conditioned on $X = i$, $R_j = |Y_j|^2$ is a chi-square random variable with two degrees of freedom, or more generally,

$$p_{R_j|X=i} = \begin{cases} \dfrac{1}{\alpha^2\gamma^2+1}\exp\left(-\dfrac{R_j+\alpha^2|d|^2}{\alpha^2\gamma^2+1}\right) I_0\left(\dfrac{2\sqrt{\alpha^2|d|^2 R_j}}{\alpha^2\gamma^2+1}\right), & j = i, \\ e^{-R_j}, & j \ne i, \end{cases} \tag{26}$$

where, as before, $\alpha^2 = PT/\nu N_0$. Note also that due to the orthogonality of signaling, the vector $\mathbf{R}$ has independent components and we denote $\mathrm{SNR} = PT/N_0$. □

Similarly to Proposition 2, we can find the infinite bandwidth capacity achieved as the number of orthogonal frequencies increases without bound. The proof is omitted as it follows along the same lines as in the proof of Proposition 2.

Proposition 4. The capacity expression (20) of M-ary OOFSK signaling in the limit as $M \uparrow \infty$ becomes

$$C_\infty^{ip}(\mathrm{SNR}) = D(p_{R|\tilde{x}} \| p_{R|\tilde{x}=0} \mid F_{\tilde{x}}), \tag{27}$$

where

$$R = |y|^2 = |h\tilde{x} + n|^2, \tag{28}$$

$\tilde{x}$ is a two-mass-point discrete random variable with mass-point locations and probabilities given in (18), and n is a zero-mean circularly symmetric complex Gaussian random variable with $E\{|n|^2\} = 1$. Therefore,

$$p_{R|\tilde{x}} = \frac{1}{\gamma^2\tilde{x}^2+1}\exp\left(-\frac{R+\tilde{x}^2|d|^2}{\gamma^2\tilde{x}^2+1}\right) \times I_0\left(\frac{2\sqrt{\tilde{x}^2|d|^2 R}}{\gamma^2\tilde{x}^2+1}\right). \tag{29}$$

The following remarks are given for the asymptotic case in which M grows to infinity.

Remark 1. Assume that in the case of perfect receiver side information, $\{h_k\}$ is a sequence of i.i.d. proper complex Gaussian random variables. Then the asymptotic loss in capacity incurred by not knowing the fading is

$$C_\infty^{p}(\mathrm{SNR}) - C_\infty^{ip}(\mathrm{SNR}) = D(p_{R|\tilde{x},|h|} \| p_{R|\tilde{x}=0,|h|} \mid p_{|h|} P_{\tilde{x}}) - D(p_{R|\tilde{x}} \| p_{R|\tilde{x}=0} \mid P_{\tilde{x}}) = I(|h|; R \mid \tilde{x}), \tag{30}$$

where $R = |h\tilde{x} + n|^2$.

Remark 2. Consider the case of imperfect receiver side information, where

$$C_{\infty}^{ip} = D\left(p_{R|\tilde{x}} \| p_{R|\tilde{x}=0} \mid P_{\tilde{x}}\right) = \left(\gamma^2 + |d|^2\right) \mathrm{SNR} - \nu \log\left(\gamma^2 \frac{\mathrm{SNR}}{\nu} + 1\right) - \frac{2\,\mathrm{SNR}\,|d|^2}{\gamma^2\,\mathrm{SNR}/\nu + 1} + \nu E_R\left\{\log I_0\left(\frac{2\sqrt{(\mathrm{SNR}/\nu)|d|^2 R}}{\gamma^2(\mathrm{SNR}/\nu) + 1}\right)\right\} \tag{31}$$

with $\mathrm{SNR} = PT/N_0$. From (31), we can easily see that for fixed symbol interval T,

$$\lim_{\nu \downarrow 0} \frac{1}{T} C_{\infty}^{ip}(\mathrm{SNR}) = \frac{1}{T}\left(\gamma^2 + |d|^2\right) \mathrm{SNR} = \left(\gamma^2 + |d|^2\right) \frac{P}{N_0} \text{ nats/s}, \tag{32}$$

and for fixed duty factor ν,

$$\lim_{T \uparrow \infty} \frac{1}{T} C_{\infty}^{ip}(\mathrm{SNR}) = \left(\gamma^2 + |d|^2\right) \frac{P}{N_0} \text{ nats/s}. \tag{33}$$

Note that right-hand sides of (32) and (33) are equal to the infinite bandwidth capacity of the unfaded Gaussian channel with the same received signal power. Hence, these results agree with previous results [5–7], where it has been shown that the capacity of M-ary FSK signaling over noncoherent fading channels approaches the infinite bandwidth capacity of the unfaded Gaussian channel for large M and large symbol duration T or small duty factor ν.

3.3. Limited peak-to-average power ratio

The peak-to-average power ratio (PAR) of OOFSK signaling is equal to the inverse of the duty factor, $1/\nu$. In this section, we examine the low-SNR behavior when we keep the duty factor fixed, while the average power P vanishes. We show that under this limited PAR condition, OOFSK communication with energy detection at low SNR values is extremely power inefficient even in the unfaded Gaussian channel.

Proposition 5. The first derivative of the capacity at zero SNR achieved by M-ary OOFSK signaling with a fixed duty factor $\nu \leq 1$ over the unfaded Gaussian channel is zero, that is, $\dot{C}_M^g(0) = 0$ and hence the bit energy required at zero spectral efficiency is infinite,

$$\left.\frac{E_b}{N_0}\right|_{C=0} = \lim_{\mathrm{SNR}\to 0} \frac{\mathrm{SNR}}{C_M^g(\mathrm{SNR})} \log_e 2 = \frac{\log_e 2}{\dot{C}_M^g(0)} = \infty. \tag{34}$$

Proof. Since we consider the unfaded Gaussian channel, we set the fading variance $\gamma^2 = 0$ in the capacity expression (20). Note that the only term in (20) that depends on the signal-to-noise ratio is $f(R_i, \mathrm{SNR}) = \exp(-|d|^2\,\mathrm{SNR}) I_0(2\sqrt{\mathrm{SNR}\,|d|^2 R_i})$ in (24). Using the fact that $\lim_{x\to 0}(I_1(a\sqrt{x})/\sqrt{x}) = a/2$ for $a \geq 0$, one can show that the derivative at $\mathrm{SNR} = 0$ is $\dot{f}(R_i, 0) = |d|^2(-1 + R_i)$. The result then follows by taking the derivative of the capacity (20) and evaluating it at $\mathrm{SNR} = 0$. □

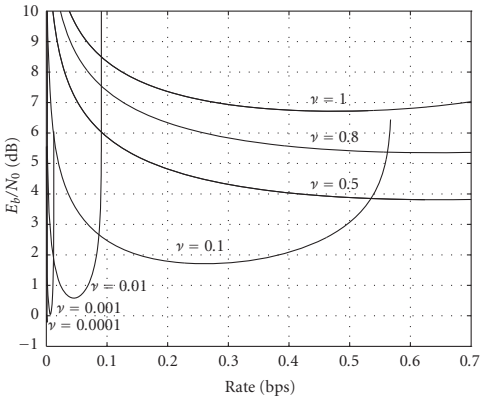

Figure 1: E_b/N_0 (dB) versus rate (bps) for the unfaded Gaussian channel. $M = 2$.

Since the presence of fading that is unknown at the transmitter does not increase the capacity, from Proposition 5, we immediately conclude that $\dot{C}(0) = 0$ for fading channels, regardless of receiver side information as long as ν is fixed and hence the peak-to-average power ratio is limited. This result indicates that operating at very low SNR is power inefficient, and the minimum bit energy of M-ary OOFSK signaling is achieved at a nonzero spectral efficiency. Proposition 5 stems from the nonconcavity of the capacity-cost function under peak-to-average constraints (see [11]). The minimum energy per bit must be computed numerically.

Figure 1 plots bit-energy curves as a function of rate in (bps) achieved in the unfaded Gaussian channel by 2-OOFSK signaling for different values of fixed duty factor ν. Notice that for all cases minimum bit-energy values are obtained at a nonzero rate and as the duty factor is decreased, the required minimum bit energy is also decreased. With $\nu = 0.0001$, the minimum bit energy is about -0.2 dB. Note that this is a significant improvement over the case $\nu = 1$, where the minimum bit energy is about 6.7 dB. However, this gain is obtained at the cost of a considerable increase in the peak-to-average ratio. Figure 2 plots the bit-energy curves in the unknown Rician channel with Rician factor K = 0.5.

3.4. Limited peak power

In this section, we consider the case where the peak level of the transmitted signal is limited, while there is no constraint on the peak-to-average power ratio. Hence we fix the peak level to the maximum allowed level, $A = P/\nu$. Therefore, as $P \to 0$, the duty factor also has to vanish and hence the peak-to-average ratio increases without bound. In this case, the minimum bit energy is achieved at zero spectral efficiency, and the wideband slope provides a good characterization of the bandwith/power tradeoff at low spectral-efficiency values.

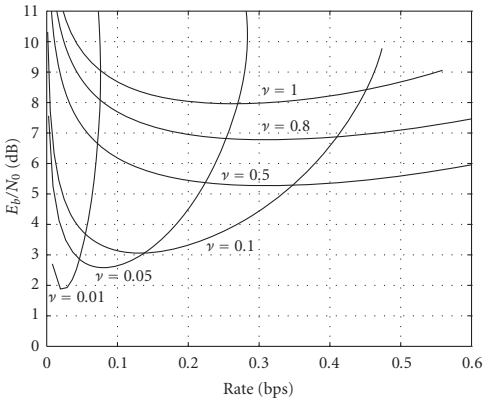

FIGURE 2: E_b/N_0 (dB) versus rate (bps) for the unknown Rician channel with K = 0.5. $M = 2$.

Proposition 6. Assume that the transmitter is limited in peak power, $P/\nu \leq A$, and the symbol duration T is fixed. Then the capacity achieved by M-ary OOFSK signaling, with fixed peak power A, is a concave function of P. For the perfect receiver side information case, the minimum received bit energy and the wideband slope are

$$\frac{E_b^r}{N_{0\,\min}} = \frac{\log_e 2}{\left(E_{|h|}E_R\{\log I_0(2\sqrt{\eta|h|^2R})\}/\eta(\gamma^2+|d|^2)\right)-1},$$
$$S_0 = \frac{2\left(E_hE_R\{\log I_0(2\sqrt{\eta|h|^2R})\}-\eta(\gamma^2+|d|^2)\right)^2}{E_h\{I_0(2\eta|h|^2)\}-1}, \tag{35}$$

respectively, where R is a noncentral chi-square random variable with

$$p_R = e^{-R-\eta|h|^2}I_0\left(2\sqrt{\eta|h|^2R}\right) \tag{36}$$

and $\eta = A(T/N_0)$ is the normalized peak power. For the imperfect receiver side information case, the minimum received bit energy and the wideband slope are

$$\frac{E_b^r}{N_{0\,\min}} = \frac{\log_e 2}{1-\left(1/(\gamma^2+|d|^2)\right)\left(2|d|^2/(\eta\gamma^2+1)+\log(\eta\gamma^2+1)/\eta - E\{\log I_0(2\sqrt{\eta|d|^2R}/(\eta\gamma^2+1))\}/\eta\right)}, \tag{37}$$

$$S_0 = \begin{cases} \dfrac{2\left(\eta(\gamma^2+|d|^2)-2\eta|d|^2/(\eta\gamma^2+1)-\log(\eta\gamma^2+1)+E\{\log I_0(2\sqrt{\eta|d|^2R}/(\eta\gamma^2+1))\}\right)^2}{1/(1-\eta^2\gamma^4)\exp\left(2\eta^2\gamma^2|d|^2/(1-\eta^2\gamma^4)\right)I_0\left(2\eta|d|^2/(1-\eta^2\gamma^4)\right)-1}, & \eta\gamma^2<1, \\ 0, & \eta\gamma^2 \geq 1, \end{cases} \tag{38}$$

respectively, where R is a noncentral chi-square random variable with

$$p_R = \frac{1}{\eta\gamma^2+1}\exp\left(-\frac{R+\eta|d|^2}{\eta\gamma^2+1}\right)I_0\left(\frac{2\sqrt{\eta|d|^2R}}{\eta\gamma^2+1}\right). \tag{39}$$

Proof. Since perfect and imperfect receiver side information cases are similar, for brevity we prove only the latter case. When we fix the peak power $A = P/\nu$, we have $\nu = \mathrm{SNR}/\eta$, and the capacity becomes

$$C_M^{ip}(\mathrm{SNR}) = \left(1-\frac{\mathrm{SNR}}{\eta}\right)\int p_{\mathbf{R}|X=0}\log\frac{p_{\mathbf{R}|X=0}}{p_{\mathbf{R}}}\,\mathrm{d}\mathbf{R} + \frac{\mathrm{SNR}}{\eta}\int p_{\mathbf{R}|X=1}\log\frac{p_{\mathbf{R}|X=1}}{p_{\mathbf{R}}}\,\mathrm{d}\mathbf{R}. \tag{40}$$

In the above capacity expression, $p_{\mathbf{R}} = (1-\mathrm{SNR}/\eta)p_{\mathbf{R}|X=0} + (\mathrm{SNR}/M\eta)\sum_{i=1}^{M} p_{\mathbf{R}|X=i}$, where $p_{\mathbf{R}|X=0}$ and $p_{\mathbf{R}|X=i}$ for $1 \leq i \leq M$, do not depend on SNR because the ratio $\mathrm{SNR}/\nu = \eta$ is a constant. Concavity of the capacityfollows from the concavity of $-x\log x$ and the fact that $p_{\mathbf{R}}$ is a linear function of SNR. Since the capacity curve is concave, the minimum received bit energy is achieved at zero spectral efficiency, $E_b^r/N_{0\min} = E\{|h|^2\}\log_e 2/\dot{C}(0)$. The wideband slope is given by (10), and depends on both the first and second derivatives of the capacity. Hence the expressions in (37) and (38) are easily obtained by evaluating

$$\dot{C}_M^{ip}(0) = \gamma^2+|d|^2-\frac{2|d|^2}{\eta\gamma^2+1}-\frac{\log(\eta\gamma^2+1)}{\eta} + \frac{E\{\log I_0(2\sqrt{\eta|d|^2R}/(\eta\gamma^2+1))\}}{\eta}, \tag{41}$$

$$\ddot{C}_M^{ip}(0) = \begin{cases} \dfrac{1}{\eta^2M}\left(1-\dfrac{1}{1-\eta^2\gamma^4}\exp\left(\dfrac{2\eta^2\gamma^2|d|^2}{1-\eta^2\gamma^4}\right)I_0\left(\dfrac{2\eta|d|^2}{1-\eta^2\gamma^4}\right)\right), & \eta\gamma^2<1, \\ -\infty, & \eta\gamma^2 \geq 1. \end{cases} \tag{42}$$

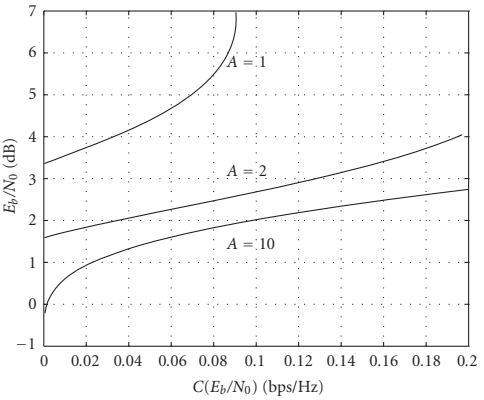

FIGURE 3: E_b/N_0 (dB) versus spectral efficiency $C(E_b/N_0)$ (bps/Hz) for the unfaded Gaussian channel. $M = 2$.

Similarly, for the perfect receiver side information case, we note that

$$\dot{C}_M^p(0) = \frac{E_{|h|}E_R\{\log I_0(2\sqrt{\eta|h|^2R})\}}{\eta} - (\gamma^2 + |d|^2),$$
$$\ddot{C}_M^p(0) = \frac{1 - E_{|h|}\{I_0(2\eta|h|^2)\}}{\eta^2 M}. \tag{43}$$

□

In contrast to the limited PAR case, the minimum bit energy is achieved at zero spectral efficiency, and hence the power efficiency of the system improves if one operates at smaller SNR and vanishing duty factor. Note in this case that, although the average power P is decreasing, the energy of FSK signals, PT/ν, is kept fixed, and the average power constraint is satisfied by sending these signals less frequently. In the imperfectly known channel, this type of peakedness introduced in time proves useful in avoiding adverse channel conditions. On the other hand, in the PAR limited case, the decreasing average power constraint is satisfied by decreasing the energy of FSK signals. Note that in the above result, for both perfect and imperfect side information cases, the minimum bit energy and the wideband slope do not depend on M. Therefore, on/off signaling with vanishing duty cycle is optimally power efficient at very low spectral-efficiency values, and there is no need for frequency modulation. Further note that in the imperfect receiver side information case, if $\eta\gamma^2 \geq 1$, then $S_0 = 0$, and hence approaching the minimum bit energy is extremely slow. If we relax the peak power limitation and let $\eta \uparrow \infty$, then it is easily seen that even in the imperfect receiver side information case, $E_b^r/N_{0\min} \to \log_e 2 = -1.59$ dB. Indeed, [11] shows in a more general setting that flash signaling with increasingly high peak power is required to achieve the minimum bit energy of -1.59 dB if the fading is not perfectly known at the receiver.

Figure 3 plots the bit-energy curves achieved by 2-OOFSK signaling in the unfaded Gaussian channel for different peak power values A. Notice that for all cases the minimum bit energy is achieved in the limit as the spectral efficiency goes to zero and this energy monotonically decreases to -1.59 dB as $A \to \infty$.

4. CAPACITY OF M-ARY OOFPSK SIGNALING

In this section, we consider joint frequency and phase modulation to improve the power efficiency of communication with OOFSK signaling. Combining phase and frequency modulation techniques has been proposed in the literature (see, e.g., [20–23]). As we have seen in the previous section, if the receiver employs energy detection and the peak-to-average power ratio is limited, then operating at very low SNR is extremely power inefficient. The peak-to-average power ratio constraint puts a restriction on the energy concentration in a fraction of time. Hence, for low average power values, the power of FSK signals is also low, and depending solely on energy detection leads to severe degradation in the performance. On the other hand, if the receiver can track phase shifts in the channel or if the received signal has a specular component as in the Rician channel, then the performance is improved at low spectral-efficiency values if information is conveyed in not only the amplitude but also the phase of each orthogonal frequency. Hence we propose employing phase modulation in OOFSK signaling. Therefore, in this section, we assume that the phase θ_i of the FSK signal,

$$s_{i,\theta_i}(t) = \sqrt{\frac{P}{\nu}}e^{j(w_i t+\theta_i)}, \quad 0 \leq t \leq T, \tag{44}$$

is a random variable carrying information. Henceforth this new signaling scheme is referred to as OOFPSK signaling. The channel input can now be represented by the pair (X, θ). If $X = i$ for $1 \leq i \leq M$, and $\theta = \theta_i$, the transmitter sends the sine wave $s_{i,\theta_i}(t)$, while no transmission is denoted by $X = 0$, and hence $s_0(t) = 0$. As another difference from Section 3, the decoder directly uses the matched filtered output vector $\mathbf{Y} = (Y_1, \ldots, Y_M)$ instead of the energy measurements in each frequency component.

4.1. Perfect receiver side information

We first consider the case where the receiver has perfect knowledge of the instantaneous realization of fading coefficients $\{h_k\}$, and obtain the capacity results both for fixed M and as M goes to infinity.

Proposition 7. Consider the fading channel model (4) and assume that the receiver perfectly knows the instantaneous values of the fading, h_k, $k = 1, 2, \ldots$, while the transmitter has no fading side information. Then the capacity of M-ary orthogonal OOFPSK signaling, with a fixed duty factor $\nu \leq 1$, is

$$C_M^p(\mathrm{SNR}) = -M - E_{|h|}\left\{(1-\nu)\int p_{\mathbf{R}|X=0}\log p_{\mathbf{R}||h|}\,\mathrm{d}\mathbf{R} + \nu\int p_{\mathbf{R}|X=1,|h|}\log p_{\mathbf{R}||h|}\,\mathrm{d}\mathbf{R}\right\}, \tag{45}$$

where $p_{\mathbf{R}||h|}$, $p_{\mathbf{R}|X=0}$, $p_{\mathbf{R}|X=i,|h|}$, and $f(R_i, |h|, \mathrm{SNR})$ for $1 \le i \le M$ are defined in (12), (13), (14), and (15), respectively.

For the Proof, see Appendix C.

Proposition 8. The capacity expression (45) of M-ary OOFPSK signaling in the limit as $M \uparrow \infty$ becomes

$$\begin{aligned} C_{\infty}^{p}(\mathrm{SNR}) &= D\left(P_{y|\tilde{x},h} \| P_{y|\tilde{x}=0,h} \,|\, F_{\tilde{x}} F_h\right) \\ &= E\{|h|^2\}\,\mathrm{SNR} \\ &= \left(\gamma^2 + |d|^2\right)\mathrm{SNR}, \end{aligned} \tag{46}$$

where $y = h\tilde{x} + n$, $\tilde{x}$ is a two-mass-point discrete random variable with mass-point locations and probabilities given in (18), and n is zero-mean circularly symmetric Gaussian random variable with $E\{|n|^2\} = 1$.

Note that $1/TC_{\infty}^{p}(\mathrm{SNR}) = (\gamma^2 + |d|^2)P/N_0$ nats/s is equal to the infinite bandwidth capacity of the unfaded Gaussian channel with the same received power. Hence, in the perfect side information case, ordinary FPSK signaling with duty factor $\nu = 1$ is enough to achieve this capacity.

4.2. Imperfect receiver side information

Similarly as in Section 3.2, we now assume that neither the receiver nor the transmitter has any fading side information and consider a more special fading process: memoryless Rician fading where each of the i.i.d. h_k's is a proper complex Gaussian random variable with $E\{h_k\} = d$ and $\mathrm{var}(h_k) = \gamma^2$. The capacity of OOFPSK signaling is given by the following result.

Proposition 9. Consider the fading channel (4) and assume that the fading process $\{h_k\}$ is a sequence of i.i.d. proper complex Gaussian random variables with $E\{h_k\} = d$ and $\mathrm{var}(h_k) = \gamma^2$, which are not known at either the receiver or the transmitter. Then the capacity of M-ary orthogonal OOFPSK signaling, with a duty factor $\nu \le 1$, is given by

$$\begin{aligned} C_{M}^{ip}(\mathrm{SNR}) = &-M - \nu \log\left(\gamma^2 \frac{\mathrm{SNR}}{\nu} + 1\right) \\ &- (1-\nu)\int p_{\mathbf{R}|X=0} \log p_{\mathbf{R}}\, \mathrm{d}\mathbf{R} \\ &- \nu \int p_{\mathbf{R}|X=1} \log p_{\mathbf{R}}\, \mathrm{d}\mathbf{R}, \end{aligned} \tag{47}$$

where $p_{\mathbf{R}}$, $p_{\mathbf{R}|X=0}$, $p_{\mathbf{R}|X=i}$, and $f(R_i, \mathrm{SNR})$ for $1 \le i \le M$ are defined in (21), (22), (23), and (24), respectively.

Proof. The proof is almost identical to that of Proposition 7. Due to the symmetry of the channel, capacity is achieved by equiprobable FSK signals with uniform phases. Note that in this case,

$$\begin{aligned} C_{M}^{ip}(\mathrm{SNR}) = &(1-\nu)\int p_{\mathbf{Y}|X=0,\theta} \log \frac{p_{\mathbf{Y}|X=0,\theta}}{p_{\mathbf{Y}}}\, \mathrm{d}\mathbf{Y} \frac{1}{2\pi}\, \mathrm{d}\theta \\ &+ \nu \int p_{\mathbf{Y}|X=1,\theta} \log \frac{p_{\mathbf{Y}|X=1,\theta}}{p_{\mathbf{Y}}}\, \mathrm{d}\mathbf{Y} \frac{1}{2\pi}\, \mathrm{d}\theta, \end{aligned} \tag{48}$$

where

$$p_{\mathbf{Y}|X=i,\theta_i} = \begin{cases} \dfrac{1}{\pi^{M-1}} e^{-\sum_{j\neq i}|Y_j|^2} \dfrac{1}{\pi(\gamma^2\alpha^2+1)} e^{-|Y_i - \alpha d e^{j\theta_i}|^2/(\gamma^2\alpha^2+1)}, & 1 \le i \le M, \\ \dfrac{1}{\pi^{M}} e^{-\sum_{j=1}^{M}|Y_j|^2}, & i = 0. \end{cases} \tag{49}$$

The capacity expression in (47) is then obtained by first integrating with respect to θ, and then making a change of variables, $R_j = |Y_j|^2$. □

Proposition 10. The capacity expression (47) of M-ary OOFPSK signaling in the limit as $M \uparrow \infty$ becomes

$$\begin{aligned} C_{\infty}^{ip}(\mathrm{SNR}) &= D\left(P_{y|\tilde{x}} \| P_{y|\tilde{x}=0} \,|\, F_{\tilde{x}}\right) \\ &= \left(\gamma^2 + |d|^2\right)\mathrm{SNR} - \nu \log\left(\gamma^2 \frac{\mathrm{SNR}}{\nu} + 1\right), \end{aligned} \tag{50}$$

where $y = h\tilde{x} + n$, h is a proper Gaussian random variable with $E\{h\} = d$ and $\mathrm{var}(h) = \gamma^2$, $\tilde{x}$ is a two-mass-point discrete random variable with mass-point locations and probabilities given in (18), and n is a zero-mean circularly symmetric complex Gaussian random variable with $E\{|n|^2\} = 1$.

Similarly as before, the remarks below are given for the asymptotic case in which $M \to \infty$.

Remark 3. Assume that in the case of perfect receiver side information, $\{h_k\}$ is a sequence of i.i.d. proper complex Gaussian random variables. Then the asymptotic loss in capacity incurred by not knowing the fading is

$$\begin{aligned} C_{\infty}^{p}(\mathrm{SNR}) - C_{\infty}^{ip}(\mathrm{SNR}) &= D\left(p_{y|\tilde{x},h} \| p_{y|\tilde{x}=0,h} \,|\, F_h F_{\tilde{x}}\right) \\ &\quad - D\left(p_{y|\tilde{x}} \| p_{y|\tilde{x}=0} \,|\, F_{\tilde{x}}\right) \\ &= I(h; y \,|\, \tilde{x}). \end{aligned} \tag{51}$$

Remark 4. Consider the case of imperfect receiver side information. For unit duty factor $\nu = 1$, the capacity expression (50) is a special case of the result by Viterbi [24]. From (50), we can also see that for fixed symbol interval T,

$$\lim_{\nu \downarrow 0} \frac{1}{T} C_{\infty}^{ip}(\mathrm{SNR}) = \frac{1}{T}\left(\gamma^2 + |d|^2\right)\mathrm{SNR} = \left(\gamma^2 + |d|^2\right)\frac{P}{N_0}\ \text{nats/s}, \tag{52}$$

and for fixed duty factor ν,

$$\lim_{T \uparrow \infty} \frac{1}{T} C_{\infty}^{ip}(\mathrm{SNR}) = \left(\gamma^2 + |d|^2\right)\frac{P}{N_0}\ \text{nats/s}. \tag{53}$$

Note that right-hand sides of (52) and (53) are equal to the infinite bandwidth capacity of the unfaded Gaussian channel with the same received signal power.

4.3. Limited peak-to-average power ratio

As in Section 3.3, we first consider the case where the transmitter peak-to-average power ratio is limited and hence the

duty factor ν is kept fixed, while the average power varies. The power efficiency in the low-power regime is characterized by the following result.

Proposition 11. Assume that the transmitter is constrained to have limited peak-to-average power ratio and the PAR of M-ary OOFPSK signaling, $1/\nu$, is kept fixed at its maximum level. Then, for the perfect receiver side information case, the minimum received bit energy and the wideband slope are

$$\frac{E_b^r}{N_0}_{\min} = \log_e 2, \qquad S_0 = \frac{2\left(E\{|h|^2\}\right)^2}{E\{|h|^4\}} = \frac{2}{\kappa(|h|)}, \tag{54}$$

respectively, where $\kappa(|h|)$ is the kurtosis of the fading magnitude. For the imperfect receiver side information case, the received bit energy required at zero spectral efficiency and the wideband slope are

$$\left.\frac{E_b^r}{N_0}\right|_{\mathrm{C}=0} = \left(1+\frac{1}{\mathrm{K}}\right)\log_e 2, \qquad S_0 = \frac{2\mathrm{K}^2}{(1+\mathrm{K})^2 - M/\nu}, \tag{55}$$

respectively, where $\mathrm{K} = |d|^2/\gamma^2$ is the Rician factor.

Proof. For brevity, we show the result only for the imperfect receiver side information case. Note that in the capacity expression (47), the only term that depends on SNR is $f(R_i, \mathrm{SNR})$. Using

$$\begin{aligned} \lim_{x\to 0} \frac{I_1(a\sqrt{x})}{\sqrt{x}} &= \frac{a}{2}, \\ \lim_{x\to 0} \frac{I_0(a\sqrt{x})}{x} - \frac{2I_1(a\sqrt{x})}{ax^{3/2}} &= \frac{a^2}{8}, \end{aligned} \tag{56}$$

one can easily show that the first and second derivatives with respect to SNR of $f(R_i, \mathrm{SNR})$ at zero SNR are

$$\begin{aligned} \dot{f}(R_i, 0) &= \frac{1}{\nu}\left(\gamma^2 + |d|^2\right)\left(-1 + R_i\right), \\ \ddot{f}(R_i, 0) &= \frac{1}{\gamma^2}\left(|d|^4 + 2\gamma^4 + 4\gamma^2|d|^2\right)\left(1 - 2R_i + \frac{R_i^2}{2}\right), \end{aligned} \tag{57}$$

respectively. Then, differentiating the capacity (47) with respect to SNR, we have

$$\dot{C}_M^{ip}(0) = |d|^2, \qquad \ddot{C}_M^{ip}(0) = -\frac{\left(\gamma^2 + |d|^2\right)^2}{M} + \frac{\gamma^4}{\nu}. \tag{58}$$

The received bit energy required at zero spectral efficiency is obtained from the formula

$$\left.\frac{E_b^r}{N_0}\right|_{\mathrm{C}=0} = \frac{\left(\gamma^2 + |d|^2\right)\log_e 2}{\dot{C}(0)}, \tag{59}$$

and the wideband slope is found by inserting the derivative expressions in (58) into (10). Similarly, for the perfect receiver side information case, we have

$$\dot{C}_M^{p}(0) = E\{|h|^2\} = \left(\gamma^2 + |d|^2\right), \qquad \ddot{C}_M^{p}(0) = -\frac{E\{|h|^4\}}{M}. \tag{60}$$

□

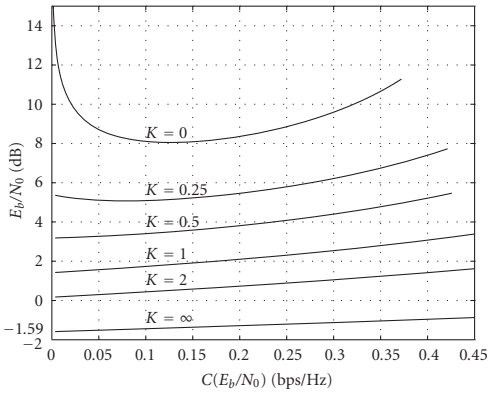

FIGURE 4: E_b/N_0 (dB) versus spectral efficiency $C(E_b/N_0)$ (bps/Hz) for the unknown Rayleigh channel (K = 0), unknown Rician channels (K = 0.25, 0.5, 1, 2), and the unfaded Gaussian channel (K = ∞) when $M = 2$ and $\nu = 1$.

Notice that in the perfect side information case, the minimum bit energy is −1.59 dB, and the wideband slope does not depend on M and ν. In fact, Verdú has obtained the same bit energy and wideband slope expression in [11] for discrete-time fading channels when the receiver knows the fading coefficients, and proved that QPSK modulation is optimally efficient achieving these values. More interesting is the imperfect receiver side information case, where the minimum bit energy is not necessarily achieved at zero spectral efficiency. Note that unlike the bit-energy expression in (55), the wideband slope is a function of M and ν, and is negative if $M/\nu > (1+\mathrm{K})^2$ in which case the minimum bit energy is achieved at a nonzero spectral efficiency.

Figure 4 plots the bit-energy curves as a function of spectral efficiency in bps/Hz for 2-FPSK signaling ($\nu = 1$). Note that for K = 0.25, the wideband slope is negative, and hence the minimum bit energy is achieved at a nonzero spectral efficiency. On the other hand, for $K = 0.5, 1, 2$, the wideband slope is positive, and hence higher power efficiency is achieved as one operates at lower spectral efficiency. Similar observations are noted from Figure 5, where bit-energy curves are plotted for 3-FPSK signaling. Figure 6 plots the bit-energy curves for 2-OOFPSK signaling with different duty cycle parameters over the unknown Rician channel with K = 1. We observe that the required minimum bit energy is decreasing with decreasing duty cycle. For instance, when $\nu = 0.01$, the minimum bit energy of ∼ 0.46 dB is achieved at the cost of a peak-to-average ratio of 100. Note also that since the received bit energy at zero spectral efficiency (55) depends only on the Rician factor K, all the curves in Figure 6 meet at the same point on the y-axis.

4.4. Limited peak power

Here we assume that the transmitter is limited in its peak power, while there is no bound on the peak-to-average power

ratio. We consider the power efficiency of M-ary OOFPSK signaling when the peak power is kept fixed at the maximum allowed level, $A = P/\nu$. Note that as the average power $P \to 0$, the duty factor ν also must vanish, thereby increasing the peak-to-average power ratio without bound. For this case, we have the following result.

Proposition 12. Assume that the transmitter is limited in peak power, $P/\nu \leq A$, and the symbol duration T is fixed. Then the capacity achieved by M-ary OOFPSK signaling with fixed peak power A is a concave function of the SNR. For the case of perfect receiver side information, the minimum received bit energy and the wideband slope are

$$\frac{E_b^r}{N_{0\,\min}} = \log_e 2, \qquad S_0 = \frac{2\eta^2\left(E\{|h|^2\}\right)^2}{E\{I_0(2\eta|h|^2)\} - 1}, \tag{61}$$

respectively, where $\eta = A(T/N_0)$ is the normalized peak power. For the case of imperfect receiver side information, the minimum received bit energy and the wideband slope are

$$\frac{E_b^r}{N_{0\,\min}} = \frac{\log_e 2}{1 - \log\left(\gamma^2\eta + 1\right)/(\gamma^2 + |d|^2)\eta},$$
$$S_0 = \begin{cases} \dfrac{2\left(\eta\left(\gamma^2 + |d|^2\right) - \log\left(\eta\gamma^2 + 1\right)\right)^2}{1/(1-\eta^2\gamma^4)\exp\left(2\eta^2\gamma^2|d|^2/(1-\eta^2\gamma^4)\right)I_0\left(2\eta|d|^2/(1-\eta^2\gamma^4)\right) - 1}, & \eta\gamma^2 < 1, \\ 0, & \eta\gamma^2 \geq 1, \end{cases} \tag{62}$$

respectively.

Proof. As before, we consider only the imperfect receiver side information case. When we fix the peak power $A = P/\nu$, we have $\nu = \mathrm{SNR}/\eta$, and the capacity becomes

$$\begin{aligned} C_M^{ip}(\mathrm{SNR}) = {} & -M - \frac{\mathrm{SNR}}{\eta}\log\left(\gamma^2\eta + 1\right) \\ & - \left(1 - \frac{\mathrm{SNR}}{\eta}\right)\int p_{\mathbf{R}|X=0}\log p_{\mathbf{R}}\,\mathrm{d}\mathbf{R} \\ & - \frac{\mathrm{SNR}}{\eta}\int p_{\mathbf{R}|X=1}\log p_{\mathbf{R}}\,\mathrm{d}\mathbf{R}. \end{aligned} \tag{63}$$

In the above capacity expression,

$$p_{\mathbf{R}} = \left(1 - \frac{\mathrm{SNR}}{\eta}\right)p_{\mathbf{R}|X=0} + \frac{\mathrm{SNR}}{M\eta}\sum_{i=1}^{M} p_{\mathbf{R}|X=i}, \tag{64}$$

where $p_{\mathbf{R}|X=0}$ and $p_{\mathbf{R}|X=i}$ for $1 \leq i \leq M$ do not depend on SNR because the ratio $\mathrm{SNR}/\nu = \eta$ is a constant. Concavity of the capacity follows from the concavity of $-x\log x$ and the fact that $p_{\mathbf{R}}$ is a linear function of SNR. Due to concavity of the capacity curve, the minimum bit energy is achieved at zero spectral efficiency. Differentiating the capacity with respect to SNR, we get

$$\dot{C}_M^{ip}(0) = \gamma^2 + |d|^2 - \frac{\log\left(\gamma^2\eta + 1\right)}{\eta}, \tag{65}$$

and $\ddot{C}_M^{ip}(0)$ having the same expression as in (42). Then, (62) is easily obtained using the aforementioned formulas for the minimum bit energy and the wideband slope. Similarly, we note for the perfect side information case that

$$\begin{aligned} \dot{C}_M^{p}(0) &= E\{|h|^2\} = \gamma^2 + |d|^2, \\ \ddot{C}_M^{p}(0) &= \frac{1 - E\{I_0(2\eta|h|^2)\}}{\eta^2 M}. \end{aligned} \tag{66}$$

□

Note that the results in (61) and (62) do not depend on M, and hence they can be achieved by pure on/off keying. Further, note that $(I_0(2\eta|h|^2) - 1)/\eta^2 > |h|^4$ for $\eta > 0$. Therefore, when the fading is perfectly known, the strategy of fixing the peak power and letting $\nu \downarrow 0$ results in a wideband slope smaller than that of fixed duty factor and hence should not be preferred. In the imperfect receiver side information case, if the peak power limitation is relaxed, that is, $\eta \uparrow \infty$, the minimum bit energy approaches -1.59 dB.

Figure 7 plots the bit-energy curves as a function of spectral efficiency for the unknown Rayleigh channel ($\mathrm{K} = 0$), unknown Rician channels ($\mathrm{K} = 0.25, 0.5, 1, 2$), and the unfaded Gaussian channel ($\mathrm{K} = \infty$) when the normalized peak power limit is $\eta = 1$. We observe that for all cases the required bit energy decreases with decreasing spectral efficiency, and therefore the minimum bit energy is achieved at zero spectral efficiency. Finally, Figures 8 and 9 plot the minimum bit-energy and wideband slope values, respectively, as functions of the normalized peak power limit η in the unknown Rician channel with $\mathrm{K} = 1$. The curves are plotted for the case in which no phase modulation is used, and the receiver employs energy detection (Section 3), and also for the scenario in which phase modulation is employed.

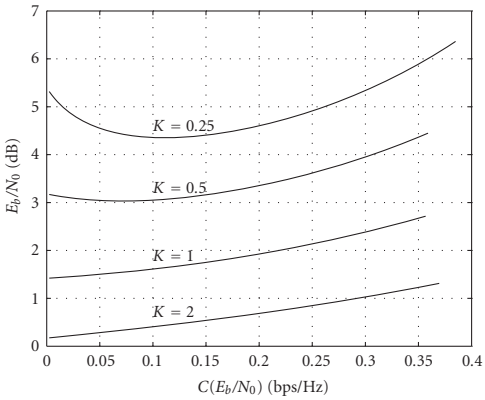

FIGURE 5: E_b/N_0 (dB) versus spectral efficiency $C(E_b/N_0)$ (bps/Hz) for unknown Rician channels (K = 0.25, 0.5, 1, 2) when $M = 3$ and $\nu = 1$.

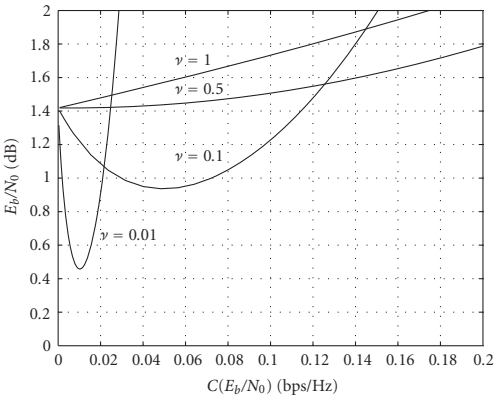

FIGURE 6: E_b/N_0 (dB) versus spectral efficiency $C(E_b/N_0)$ (bps/Hz) for the unknown Rician channel with K = 1 for $\nu = 1, 0.5, 0.1, 0.01$ when $M = 2$.

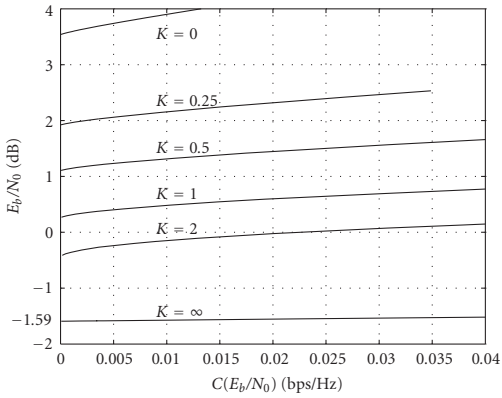

FIGURE 7: E_b/N_0 (dB) versus spectral efficiency $C(E_b/N_0)$ (bps/Hz) for the unknown Rayleigh channel (K = 0), unknown Rician channels (K = 0.25, 0.5, 1, 2), and the unfaded Gaussian channel (K = ∞) when $M = 2$ and fixed peak limit $\eta = 1$.

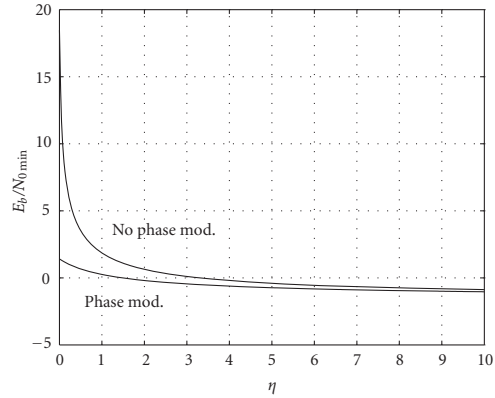

FIGURE 8: $E_b/N_{0\min}$ versus normalized peak power limit η in the unknown Rician channel with K = 1.

5. CONCLUSION

We have considered transmission of information over wideband fading channels using M-ary orthogonal on/off FSK (OOFSK) signaling, in which M-ary FSK signaling is overlaid on top of on/off keying. We have first assumed that the receiver uses energy detection for the reception of OOFSK signals. We have obtained capacity expressions when the receiver has perfect and imperfect fading side information both for fixed M and as M goes to infinity. We have investigated power efficiency when the transmitter is subject to a peak-to-average power ratio (PAR) limitation or a peak power limitation. It is shown that under a PAR limitation, no matter how large the transmitted energy per information bit is, reliable communication is impossible for small enough spectral efficiency even in the unfaded Gaussian channel, and hence it is extremely power inefficient to operate in the very low SNR regime. On the other hand, if there is only a peak power limitation, we have demonstrated that power efficiency improves as one operates with smaller SNR and vanishing duty factor. We note that, in this case, on/off keying (OOK) is an optimally efficient signaling in the low-power regime achieving the minimum bit energy and the wideband slope in both perfect and imperfect channel side information cases, while combined OOK and FSK signaling is required to improve energy efficiency when a constraint is imposed on the PAR.

We have also considered joint frequency-phase modulation schemes where the phase of the FSK signals are also used to convey information. Similarly, we have analyzed the capacity and power efficiency of these schemes. Assuming

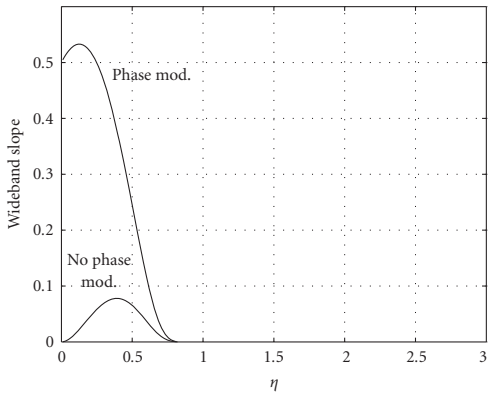

Figure 9: Wideband slope S_0 versus normalized peak power limit η in the unknown Rician channel with K = 1.

perfect channel knowledge at the receiver, we have obtained the minimum bit-energy and wideband slope expressions. In this case, it is shown that FSK signaling is not required for optimum power efficiency in the low-power regime as pure phase modulation in the PAR limited case and OOK in the peak power limited case achieve both the minimum bit energy and the optimal wideband slope. For the case in which the receiver has imperfect channel side information and the input is subject to PAR constraints, we have shown that if $M/\nu > (1 + \mathrm{K})^2$, then the wideband slope is negative, and hence the minimum bit energy is achieved at a nonzero spectral efficiency, $\mathrm{C}^* > 0$. It is concluded that, in these cases, operating in the region, where $\mathrm{C} < \mathrm{C}^*$, should be avoided. We also note that, in general, the combined OOK and FSK signaling performs better and indeed if the number of orthogonal frequencies, that is, M, is increased, then a smaller minimum bit-energy value is achieved. Furthermore, for the case in which only the peak power is limited with no constraints on the peak-to-average ratio, we have investigated the spectral-efficiency/bit-energy tradeoff in the low-power regime by obtaining both the minimum bit energy (attained at zero spectral efficiency) and the wideband slope which can be achieved by pure OOK signaling.

APPENDIX

A. PROOF OF PROPOSITION 1

Since the fading coefficients form a stationary ergodic process, the capacity of OOFSK signaling can be formulated as follows:

$$C(\mathrm{SNR}) = \lim_{n\to\infty} \max_{X^n} \frac{1}{n} I\left(X^n; \mathbf{R}^n \,\middle|\, |h|^n\right), \tag{A.1}$$

where $X^n = (X_1, \ldots, X_n)$, $\mathbf{R}^n = (\mathbf{R}_1, \ldots, \mathbf{R}_n)$, and $|h|^n = (|h_1|, \ldots, |h_n|)$. As the additive Gaussian noisesamples are independent for each symbol interval, the conditional output density satisfies

$$p_{\mathbf{R}^n|X^n,|h|^n} = \prod_{k=1}^{n} p_{\mathbf{R}_k|X_k,|h_k|}, \tag{A.2}$$

where

$$p_{\mathbf{R}_k|X_k=i,|h_k|} = \begin{cases} e^{-\sum_{j=1}^{M} R_{kj}} e^{-\alpha^2|h_k|^2} I_0\left(2\sqrt{R_{ki}\alpha^2|h_k|^2}\right), & 1 \le i \le M, \\ e^{-\sum_{j=1}^{M} R_{kj}}, & i = 0, \end{cases} \tag{A.3}$$

with $\alpha^2 = PT/\nu N_0 = \mathrm{SNR}/\nu$. From the above fact, one can easily show that

$$\begin{aligned} I\left(X^n; \mathbf{R}^n \,\middle|\, |h|^n\right) &= \sum_{k=1}^{n} I\left(X_k; \mathbf{R}_k \,\middle|\, |h_k|\right) \\ &\quad - D\left(p_{\mathbf{R}^n||h|^n} \,\middle\|\, \prod_{k=1}^{n} p_{\mathbf{R}_k||h_k|} \,\middle|\, F_{|h|^n}\right) \\ &\le \sum_{k=1}^{n} I\left(X_k; \mathbf{R}_k \,\middle|\, |h_k|\right), \end{aligned} \tag{A.4}$$

where $D(\cdot||\cdot F_{|h|^n})$ denotes the conditional divergence. The above upper bound is achieved if the input vector $X^n = (X_1, \ldots, X_n)$ has independent components. Due to the symmetry of the channel, an input distribution equiprobable over nonzero input values, that is, $P(X_k = i) = \nu/M$ for $1 \le i \le M$, where $P(X_k = 0) = 1 - \nu$, maximizes $I(X_k; \mathbf{R}_k \mid |h_k|)$ for each k. To see this, note that since the mutual information is a concave function of the input vector, a sufficient and necessary condition for an input vector to be optimal is

$$\frac{\partial}{\partial P_i}\left[I\left(X_k; \mathbf{R}_k \,\middle|\, |h_k|\right) - \lambda\left(\sum_{j=1}^{M} P_j - \nu\right)\right] = 0, \quad 1 \le i \le M, \tag{A.5}$$

where λ is a Lagrange multiplier for the equality constraint $\sum_{j=1}^{M} P_j = \nu$, and P_j denotes $P(X_k = j)$ for $1 \le j \le M$. Note that the duty factor is fixed, and hence $P(X = 0) = 1 - \nu$ is a predetermined constant. Evaluating the derivatives, the above condition can be reduced to

$$E_{|h_k|}\left\{\int p_{\mathbf{R}_k \,|\, X_k=i,|h_k|} \log \frac{p_{\mathbf{R}_k|X_k=i,|h_k|}}{p_{\mathbf{R}_k \,|\, |h_k|}} \, d\mathbf{R}_k\right\} - 1 = \lambda, \quad 1 \le i \le M, \tag{A.6}$$

and due to the symmetry of the channel, letting $P_i = P(X_k = i) = \nu/M$ for $1 \le i \le M$satisfies the condition. Therefore, an

i.i.d. input sequence with the above distribution achieves the capacity. The capacity expression in (11) is easily obtained by evaluating the mutual information achieved by the optimal input, considering a generic symbol interval, and dropping the time index k.

B. PROOF OF PROPOSITION 2

The method of proof follows primarily from [25], where martingale theory is used to establish a similar result for M-ary FSK signaling over the noncoherent Gaussian channel. The capacity expression in (11) can be rewritten as

$$\begin{aligned} C_M^p(\mathrm{SNR}) = {} & \nu E_{|h|}\left\{\int e^{-R-(\mathrm{SNR}/\nu)|h|^2} I_0\left(2\sqrt{\frac{\mathrm{SNR}}{\nu}|h|^2 R}\right)\log\frac{e^{-R-(\mathrm{SNR}/\nu)|h|^2} I_0\left(2\sqrt{(\mathrm{SNR}/\nu)|h|^2 R}\right)}{e^{-R}}\,\mathrm{d}R\right\} \\ & - E_{|h|}\left\{\int e^{-\sum_{i=1}^{M} R_i}\frac{S_M(\mathbf{R})}{M}\log\frac{S_M(\mathbf{R})}{M}\,\mathrm{d}\mathbf{R}\right\}, \end{aligned} \tag{B.1}$$

where the first term on the right-hand side can be recognized as the conditional divergence $D(p_{R|\tilde{x},|h|}\,\|\,p_{R|\tilde{x}=0,|h|}\,|F_{|h|}F_{\tilde{x}})$, and

$$S_M(\mathbf{R}) = \sum_{i=1}^{M}\left(\nu f(R_i, |h|, \mathrm{SNR}) + (1-\nu)\right) \tag{B.2}$$

is a sum of i.i.d. random variables. The following result is noted in [25].

Lemma 1. *Let $X_1, X_2, \ldots$ be identically distributed random variables having finite mean. Let $S_n = X_1 + \cdots + X_n$, and $\beta_n = \beta(S_n, S_{n+1}, \ldots)$, the Borel field generated by $S_n, S_{n+1}, \ldots$. Then $\{\ldots, S_n/n, S_{n-1}/n-1, \ldots, S_1/1\}$ is a martingale with respect to $\{\ldots, \beta_n, \beta_{n-1}, \ldots, \beta_1\}$. Moreover, if g is a function which is convex and continuous on a convex set containing the range of X_1, and if $E\{|g(X_1)|\} < \infty$, then $\{g(S_n/n)\}_\infty$ is a submartingale.*

From Lemma 1, we conclude that

$$\chi_M = g\left(\frac{S_M(\mathbf{R})}{M}\right) = \frac{S_M(\mathbf{R})}{M}\log\frac{S_M(\mathbf{R})}{M} \tag{B.3}$$

is a submartingale, and hence from the martingale convergence theorem [26], χ_M converges to a limit χ_∞ almost surely and in mean. Therefore, $\lim_{M\to\infty} E\{\chi_M\} = E\{\lim_{M\to\infty}\chi_M\} = E\{\chi_\infty\}$. Note also that from the strong law of large numbers and continuity of the function $g(x) = x\log x$,

$$\begin{aligned} \lim_{M\to\infty}\chi_M &= \lim_{M\to\infty} g\left(\frac{S_M(\mathbf{R})}{M}\right) = g\left(\lim_{M\to\infty}\frac{S_M(\mathbf{R})}{M}\right) \\ &= g\left(E_R\{\nu f(R, |h|, \mathrm{SNR}) + (1-\nu)\}\right) \\ &= g\left(\int e^{-R}\left(\nu f(R, |h|, \mathrm{SNR}) + (1-\nu)\right)\mathrm{d}R\right) \\ &= g(1) = 0. \end{aligned} \tag{B.4}$$

Hence, we conclude that

$$\lim_{M\to\infty} E_{\mathbf{R}}\left\{\left(\frac{S_M(\mathbf{R})}{M}\right)\log\left(\frac{S_M(\mathbf{R})}{M}\right)\right\} = 0. \tag{B.5}$$

The first term on the right-hand side of (B.1) does not depend on M, and the second term can be expressed as $E_{|h|}E_{\mathbf{R}}\{(S_M(\mathbf{R})/M)\log(S_M(\mathbf{R})/M)\}$. The proof is completed by showing that

$$\begin{aligned} &\lim_{M\to\infty} E_{|h|}E_{\mathbf{R}}\left\{\frac{S_M(\mathbf{R})}{M}\log\frac{S_M(\mathbf{R})}{M}\right\} \\ &\quad = E_{|h|}\left\{\lim_{M\to\infty} E_{\mathbf{R}}\left\{\frac{S_M(\mathbf{R})}{M}\log\frac{S_M(\mathbf{R})}{M}\right\}\right\} = 0, \end{aligned} \tag{B.6}$$

where the interchange of limit and expectation needs to be justified by invoking the Dominated Convergence Theorem. Note that since $\{(S_M(\mathbf{R})/M)\log(S_M(\mathbf{R})/M)\}$ is a submartingale,

$$0 \le E_{\mathbf{R}}\left\{\frac{S_M(\mathbf{R})}{M}\log\frac{S_M(\mathbf{R})}{M}\right\} \le E_R\{S_1(R)\log S_1(R)\} < \infty. \tag{B.7}$$

By noting that $f(R, |h|, \mathrm{SNR})$ is an exponentially decreasing function of $|h|$, it can be easily shown that

$$\int E_R\{S_1(R)\log S_1(R)\}\mathrm{d}F_{|h|} < \infty \tag{B.8}$$

for any distribution function $F_{|h|}$ with $E\{|h|^2\} < \infty$. Therefore, the Dominated Convergence Theorem applies using the integrable upper bound $E_R\{S_1(R)\log S_1(R)\}$.

C. PROOF OF PROPOSITION 7

Similarly to the proof of Proposition 1, an i.i.d. input sequence achieves the capacity and due to the symmetry of the channel, equiprobable FSK signals each having uniformly distributed phases are optimal. Now, the maximum input-output mutual information is

$$\begin{aligned} I(X, \theta; \mathbf{Y}|h) = E_h\Bigg\{ & (1-\nu)\int p_{\mathbf{Y}|X=0,\theta}\log\frac{p_{\mathbf{Y}|X=0,\theta}}{p_{\mathbf{Y}||h|}}\,\mathrm{d}\mathbf{Y}\frac{1}{2\pi}\,\mathrm{d}\theta \\ & + \nu\int p_{\mathbf{Y}|X=1,\theta,|h|}\log\frac{p_{\mathbf{Y}|X=1,\theta,|h|}}{p_{\mathbf{Y}||h|}}\,\mathrm{d}\mathbf{Y}\frac{1}{2\pi}\,\mathrm{d}\theta\Bigg\}, \end{aligned} \tag{C.1}$$

where

$$p_{\mathbf{Y}|X=i,\theta_i,h} = \begin{cases} \dfrac{1}{\pi^{M-1}} e^{-\sum_{j\neq i}|Y_j|^2} \left(\dfrac{1}{\pi}\right) e^{-|Y_i-\alpha h e^{j\theta_i}|^2}, & 1 \le i \le M, \\ \left(\dfrac{1}{\pi^M}\right) e^{-\sum_{j=1}^{M}|Y_j|^2}, & i = 0. \end{cases} \tag{C.2}$$

In the above formulation, $\alpha^2 = PT/\nu N_0 = \mathrm{SNR}/\nu$. It can be easily seen that

$$\int p_{\mathbf{Y}|X=i,\theta} \log p_{\mathbf{Y}|X=i,\theta}\, \mathrm{d}\mathbf{Y} \frac{1}{2\pi}\, \mathrm{d}\theta = -\log(\pi e)^M, \quad 0 \le i \le M. \tag{C.3}$$

The capacity expression in (45) is then obtained by first integrating

$$\int p_{\mathbf{Y}|X=0,\theta} \log p_{\mathbf{Y}}\, \mathrm{d}\mathbf{Y} \frac{1}{2\pi}\, \mathrm{d}\theta, \qquad \int p_{\mathbf{Y}|X=1,\theta} \log p_{\mathbf{Y}}\, \mathrm{d}\mathbf{Y} \frac{1}{2\pi}\, \mathrm{d}\theta, \tag{C.4}$$

with respect to θ and then making a change of variables, $R_j = |Y_j|^2$.

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DISCLAIMER

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Special Issue on

Advances in Single Carrier Block Modulation with Frequency Domain Processing

CALL FOR PAPERS

WiMAX, based on IEEE standard 802.16 was first developed for broadband internet access to stationary terminals and further enhanced for transmission to and from mobiles. A competing standard for broadband wireless access is 3GPP-LTE extension of the 3GPP standards. Both use OFDMA for downlink transmissions. WiMAX uses OFDMA for the uplink while LTE uses single carrier frequency division multiple access (SC-FDMA) for the uplink. This special issue focuses on variations of single carrier block modulation (SC-BM) with frequency domain processing. These variations are in the family of "generalized multi-carrier" transmission schemes and include designations such as SC-FDMA, DFT- precoded OFDMA, interleaved FDMA, and SC-BM.

The main reason for adapting the technology of SC-FDMA for uplink LTE is its low "peak to average power ratio" (PAPR), which is an advantage for mobile devices. Besides, it has almost the same performance as OFDMA, similar complexity, and simple frequency domain equalization for combating dispersive channels.

Recently, many researchers have been studying different aspects of SC-FDMA comparing its performances to other technologies, applying it to more complex channels, such as MIMO, with STC, CDMA spreading, and so forth.

We anticipate that this special issue will become a forum for researchers to summarize recent developments and ideas in this new technology. We invite authors to submit their original research articles, as well as review articles. Topics to be covered include, but not limited to:

- Theoretical aspects of SC-BM
- PAPR characteristics and reduction techniques
- Performance evaluation
- Transmit precoding, Tomlinson-Harashima Precoding (THP) and implementation
- Equalization for SC-BM
- Extension to MIMO
- Multiple access techniques
- SC-BM for optical transmission

- SC-BM with CDMA spreading
- SC-FDMA under high mobility (e.g., ICI mitigation and channel estimation)
- Mitigation of RF impairments in SC-FDMA (e.g., phase noise, I/Q imbalance)
- Resource allocation algorithms for SC-FDMA (e.g., localized versus distributed bandwidth allocations)
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Special Issue on

Advances in Two-Dimensional Angle-of-Arrival Processing for Localization and Communications

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Our ability to determine the direction-of-arrival of a transmitted signal via antenna arrays has improved dramatically in recent years. The invention of the multiple signal classification (MUSIC) and estimation of signal parameters via rotational invariant techniques (ESPRIT) algorithms revolutionized this field, demonstrating performance exceeding that prescribed by the array dimensions (so-called "superresolution"). As long as a line-of-sight component exists in the channel, the angle-of-arrival approach can be used for direction-finding or position determination for cooperative or noncooperative emitters. Applications include tracking of airborne targets from ground stations, tracking of ground-based targets from aerial platforms, search and rescue operations, emergency caller location via cell towers, precision aircraft navigation and landing, sonar source localization, and future location-based services in cellular networks. Most textbook treatments of this topic cover only "one-dimensional" angle estimation, implying that the source's movement takes place in the plane of the array. The extension to two-dimensional AOA (azimuth and elevation) is not only necessary for many real-world applications but also introduces many new problems and challenges that do not occur in the "1D" case. Specific examples include the need for so-called "pair matching" between two sets of independently obtained arrival angles, complexity reduction in approaches requiring a 2D search, and nonplanar array design. In addition, angular measurements may be combined with other modalities, such as Doppler or delay to aid 2D direction-finding or 3D location determination and prediction. We invite authors to submit their original manuscripts in this field, with particular emphasis on, but not limited to:

- Algorithms solving array calibration or coupling issues in 2D, such as blind algorithms, or spatial signature estimation
- Algorithms for improved robustness to angular multipath or identification of direct/nondirect paths
- Theoretical bounds on 2D angle estimation
- Extensions of well-known techniques such as Music, Esprit, IQML, and Propagator Method to 2D, including Higher-Order Statistics

- "Pair matching" approaches to apply multiple 1D estimations to the 2D problem for multiple sources
- Algorithms to determine the number of sources
- Novel array geometries and exploitation of array symmetries
- Complexity reduction for IQML or other search-based schemes
- Approaches combining AOA with TOA, TDOA, FOA, or other multidimensional measurements, such as joint angle-Doppler or angle-delay
- Application of 2D AOA to spatial channel estimation, prediction, modeling, or MIMO communication
- Use of 2D angle/location information to improve scheduling or networking

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Special Issue on

Cooperative MIMO Multicell Networks

CALL FOR PAPERS

Recently, the pressing desire to provide cost-effective solutions aimed at supporting high-throughput broadband wireless access with large-scale coverage has significantly changed the notion of the traditional cellular systems. Physical (PHY) layer cooperation serves as an enabling technology for such a change. In latest cellular networks, neighboring infrastructure stations, such as base stations (BSs) or relay stations (RSs), share their communication resources to create virtual multiple-input multiple-output (MIMO) systems by means of distributed transmission and signal processing. Cooperative processing at the BSs promises to exceed the limits on spectral efficiency imposed by intercell interference, thereby allowing ever more aggressive frequency reuse patterns. On the other hand, cooperation between BSs and RSs, as well as among RSs, is expected to extend coverage and capacity of point-to-multipoint links between BSs and mobile stations in a highly economical fashion. However, to achieve such benefits in practice, numerous research challenges have to be tackled. Therefore, we invite authors to present original and unpublished articles that will report cutting-edge research achievements in cooperative MIMO multicell systems. Potential topics include but are not limited to:

- Modeling of distributed MIMO channels in multicell systems
- Architectures for cooperative multicell networks
- Precoding and decoding designs for MIMO multicell systems
- Distributed space-time coding for cooperative multicell applications
- Channel training, pilot design, feedback, and synchronization for cooperative MIMO cellular networks
- Relaying strategies for multicell systems
- Cross-layer PHY/medium access control (MAC) designs for multicell networks
- Cooperative intercell interference coordination and mitigation
- Scheduling policies in cooperative cellular systems
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Special Issue on

Biologically Inspired Signal Processing: Analyses, Algorithms and Applications

CALL FOR PAPERS

Many of the problems that one encounters in Engineering have already been solved by nature. Having dealt with these problems for millions of years, the solutions that the natural evolutionary processes have developed are, in most cases and by many criteria, far superior to what we can achieve with our current engineering knowledge and methods. This is certainly true in the field of signal processing. As a case in point, bats use ultrasonic waves to navigate, forage, locate, and hunt their prey. They do this with great success, a matter that is crucial for their survival. Therefore, understanding how nature does what it has perfected over such a long time, which solutions it has selected and which solutions it has discarded will inspire Advances in Signal Processing research.

This special issue aims to provide a platform for reporting advances in the study of biological signals and systems from a signal processing point of view. We invite authors to submit original research papers as well as review articles that will enhance the research efforts in (1) algorithms and technologies for the study and understanding of biological signals and systems, (2) biologically inspired artificial signals and systems, and (3) their applications. Suggested topics include, but are not limited to:

- Biological signal analysis methods
- Spectral estimation for biological signals
- Biological signal enhancement
- Biosonar, and other biological location and navigation systems
- Characterization, analysis, and interpretation of biological signals and echolocation calls such as, but not limited to, those of bats and dolphins
- Biological target detection, identification, and tracking
- Biologically inspired signal processing algorithms
- Application areas such as, but not limited to, navigation, target detection, chemical sensing, sensor networks, radar, cochlear, and so forth.

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Special Issue on

Recent Advances in Theory and Methods for Nonstationary Signal Analysis

CALL FOR PAPERS

All physical processes are nonstationary. When analyzing time series, it is well to remember that nature can be amazingly complexed and that many of the theoretical constructs used in stochastic process theory, for example, linearity, ergodicity, normality, and particularly stationarity, are mathematical fairy tales. For example, there are, by virtue of the "big bang" if nothing else, no stationary time series in the strict mathematical sense. Thus, while it is necessary to know the theory of stationary processes, one should not adhere to it dogmatically when analyzing data from physical sources, particularly when the observations span an extended period. Nonstationary signals are appropriate models for signals arising in several fields of applications including communications, speech and audio, mechanics, geophysics, climatology, solar and space physics, optics, and biomedical engineering. Nonstationary models account for possible time variations of statistical functions and/or spectral characteristics of signals. Thus, they provide analysis tools more general than the classical Fourier transform for finite-energy signals or the power spectrum for finite-power stationary signals.

Nonstationarity, being a "nonproperty", has been analyzed from several different points of view. Several approaches that generalize the classical Fourier transform analysis have been considered, including time-frequency, time-scale, as well as wavelets analysis, fractional Fourier transform, and linear canonical transform analysis. Approaches that generalize the power-spectrum analysis include cyclostationary signal analysis, self-similar signal analysis, multitaper spectral estimation, and evolutionary spectral analysis. In addition, techniques such as adaptive system and signal analysis, empirical mode decomposition, and other data-driven methods have been used with the purpose of modeling nonstationary phenomena. The aim of this special issue is to address recent advances in the theory and methodology for nonstationary signal analysis, compare different approaches, propose emerging or new techniques, and explore new application fields. Overviews, theoretical results, and applications contributions are welcome. Topics of interest include, but are not limited to, the following:

- Time-frequency and time-scale analysis
- Wavelets analysis

- Multitaper spectral estimation
- Fractional Fourier transform and linear canonical transform analysis
- Cyclostationary signal analysis
- Self-similar signal analysis
- Evolutionary spectral analysis
- Adaptive system and signal analysis
- Empirical mode decomposition and other data-driven methods

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Special Issue on

Theory and Application of General Linear Image Processing

CALL FOR PAPERS

When studying images formed by transmitted or reflected light or observed by the human visual perception system, it is not rigorous to be constrained to the usual mathematical definition of linearity. This implies that the conventional addition "+" and scalar multiplication "x" operations are not optimal for these types of images. The major reason is that the superposition of such images does not obey the classical additive law. Therefore, although the classical linear approach has played a central role in image processing, it is not necessarily the best and even the right choice.

The general linear image processing (GLIP) framework has been introduced to overcome these problems. Indeed, by using abstract linear algebra it is possible to develop entirely new general linear operations (addition, scalar multiplication, convolution, etc.) in order to describe how images are combined, amplified, and transformed. For example, specific derivatives and integrals can be introduced allowing gradients or Laplacians, filtering and Fourier or wavelet transforms in the GLIP sense to be formulated. The GLIP framework has been shown to be consistent with physical image models, namely, the reflectance and transmittance image formation processes. The GLIP framework is also consistent with several human visual perception laws and characteristics such as Weber's and Fechner's brightness laws and the psychophysical contrast.

This special issue aims at presenting the recent theoretical and practical advances in general linear image processing (GLIP). Original research articles as well as review articles are welcome. Since image processing is a multidisciplinary field, potential authors from various scientific communities including mathematics, physics, computer science, and engineering are encouraged to submit their research work to this special issue in order to promote a comprehensive forum. The guest editors seek to gather high-quality, original, state-of-the-art, and unpublished research contributions. Topics of interest include (listed by alphabetical order), but are not limited to:

- General linear image formation models
- Gray level or color image vector spaces or other general linear structures
- Human-vision-based general linear image processing
- Image quality evaluation using general linear models

- Logarithmic and homomorphic image processing
- Applications of general linear image processing

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Special Issue on

Emotion and Mental State Recognition from Speech

CALL FOR PAPERS

As research in speech processing has matured, attention has shifted from linguistic-related applications such as speech recognition towards paralinguistic speech processing problems, in particular the recognition of speaker identity, language, emotion, gender, and age. Determination of emotion or mental state is a particularly challenging problem, in view of the significant variability in its expression posed by linguistic, contextual, and speaker-specific characteristics within speech.

Some of the key research problems addressed to date include isolating emotion-specific information in the speech signal, extracting suitable features, forming reduced-dimension feature sets, developing machine learning methods applicable to the task, reducing feature variability due to speaker and linguistic content, comparing and evaluating diverse methods, robustness, and constructing suitable databases. Automatic detection of other types of mental state, which share some characteristics with emotion, are also now being explored, for example, depression, cognitive load, and "cognitive epistemic" states such as interest or skepticism. Topics of interest in this special issue include, but are not limited to:

- Signal processing methods for acoustic feature extraction in emotion recognition
- Robustness issues in emotion classification, including speaker and speaker group normalization and reduction of mismatch due to coding, noise, channel, and transmission effects
- Applications of prosodic and temporal feature modeling in emotion recognition
- Novel pattern recognition techniques for emotion recognition
- Automatic detection of depression or psychiatric disorders from speech
- Methods for measuring stress, emotion-related indicators, or cognitive load from speech
- Studies relating speech production or perception to emotion and mental state recognition
- Recognition of nonprototypical spontaneous and naturalistic emotion in speech
- New methods for multimodal emotion recognition, where nonverbal speech content has a central role

- Emotional speech synthesis research with clear implications for emotion recognition
- Emerging research topics in recognition of emotion and mental state from speech
- Novel emotion recognition systems and applications
- Applications of emotion modeling to other related areas, for example, emotion tolerant automatic speech recognition and recognition of nonlinguistic vocalizations

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Special Issue on

Musical Applications of Real-Time Signal Processing

CALL FOR PAPERS

In the recent years, musical signal processing applications have greatly expanded the palette of artistic expression by creating a myriad of new possibilities for music and sound creation and manipulation, as well as music listening. Home recording studios have greatly benefited, as virtually all of the tools needed for music production are now available as inexpensive software. In addition to generating abstract "electronic" sounds, modern synthesis techniques can convincingly simulate many wind, string and percussion instruments, and work on the singing voice is generating promising results. Artificial reverberation, pitch shifting, equalization, dynamic range compression, and other audio signal processing techniques in turn have enabled specialized manipulation of recorded and synthetic sounds for artistic as well as fixative purposes. Sophisticated compression, noise canceling, equalization, and bass enhancement algorithms can provide noise-free, high-quality audio for portable music players.

The ongoing pursuit for both creative and realistic sounds and processing nowadays includes real-time sound synthesis and control, spatial sound, and realistic emulation of analog and vintage effects devices and synthesizers, especially with strongly nonlinear and time-varying behavior. The aim of this special issue is to present current research advances in real-time musical signal processing applications. Prospective papers should be unpublished, and present novel, fundamental research offering innovative contributions from a methodological or an application perspective. The expected scope of manuscripts for this special issue includes, but is not limited to:

- Sound synthesis techniques and synthesis control
- Musical instrument and singing voice synthesis
- Equalization and filtering, dynamic range compression, delay and distortion algorithms
- Virtual analog and vintage audio effects
- Reverberation synthesis, measurement and perception
- Analysis of musical instrument sounds for real-time synthesis
- Performance gesture measurement, analysis and synthesis
- Active noise control in portable music players

- Microphone and loudspeaker arrays
- Bandwidth expansion and bass enhancement
- Music loudness estimation
- Synthesis and computer music languages
- Audio coding
- Hardware and software implementations

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Special Issue on

Power-Aware Embedded and Real-Time Systems

CALL FOR PAPERS

Power awareness has become a main challenge for embedded and real-time systems that have stringent requirements for task timeliness, battery lifetime, and system reliability. Since there exists a fundamental tradeoff between energy and other quality attributes (or non-functional behaviors), for example, the overall system performance, power, and temperature must be properly managed to achieve requirements on real-time performance, maximum generated heat, electricity, and cooling costs. In addition, maximized system up-time and availability are important for battery-powered embedded systems. With the continuously decreasing feature size and the increasing demand for computation capabilities, today's embedded and real time systems also face an increasing risk of thermal failure, for example, overheating. It is, therefore, critical that power consumption and system temperature are explicitly addressed when designing dependable and performance-critical systems. This special issue of the EURASIP Journal of Embedded Systems is intended to present significant research results in the area of power/ thermal-aware embedded and real-time systems. Potential topics include but are not limited to:

- Power/thermal-aware task scheduling algorithms
- Power/energy optimization and management in different layers
- Architectural support for power/energy-efficient embedded and real-time systems
- Novel compilation and program optimization techniques for energy/power efficiency
- Power/energy-efficient protocol design for networked embedded systems, such as wireless sensor networks
- Power-aware cyber-physical systems

Submissions to this special issue must represent original material that has been neither submitted to nor published in any other journal. Extended versions of papers previously published in conference proceedings, digests, or preprints may be eligible for consideration, as long as the authors submit a detailed list of the extensions together with the submitted version and the extensions comprise at least 25% of novel material over prior published papers.

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journal Manuscript Tracking System at http://mts.hindawi.com/ according to the following timetable:

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Special Issue on

Emerging Methods for Color Image and Video Quality Enhancement

CALL FOR PAPERS

Digital color imaging devices, ranging from the low-end camera phones to the high-end digital cinema cameras, are ubiquitous in the current e-world. The image/video quality, including the color fidelity, resolution, signal-to-noise ratio, and sharpness, is among the most common concerns of the consumers. Therefore, how to improve the quality of digital images/videos is an important topic in both academia and industry. In the recent years, many new image processing techniques, such as nonlocal means, collaborative filtering, sparse coding, and dictionary learning, have been proposed. These techniques can provide new solutions to the resolution and quality enhancement of color images and videos.

The main focus of this special issue will be on the recent advances in theory and algorithm for color image and video quality enhancement. We welcome authors to submit their original research articles or comprehensive reviews in the related areas. This special issue is expected to be an effective channel for researches to report their latest results and findings in color image and video processing and propose new ideas and directions for the future development. The topics include, but are not limited to:

- Nonlocal techniques in color image/video processing
- Sparse coding and dictionary learning for color image/video processing
- Inpainting, interpolation, and superresolution
- Multiframe acquisition and merging
- Image sequence processing and video stabilization
- Color demosaicking and temporal color demosaicking
- Color cross-talk reduction
- Color enhancement by semantic analysis of scene content
- Color processing and enhancement for embedded systems
- Bioinspired color image/video processing methods
- Full-reference, reduced-reference, and no-reference color image/video quality assessment

Before submission authors should carefully read over the journal's Author Guidelines, which are located at http://www.hindawi.com/journals/ivp/guidelines.html. Prospective authors should submit an electronic copy of their complete manuscript through the

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Special Issue on

Advanced Video-Based Surveillance

CALL FOR PAPERS

Over the past decade, we have witnessed a tremendous growth in the demand for personal security and defense of vital infrastructure throughout the world. At the same time, rapid advances in video-based surveillance have emerged and offered a strategic technology to address the demands imposed by security applications. These events have led to a massive research effort devoted to the development of effective and reliable surveillance systems endowed with intelligent video-processing capabilities. As a result, advanced video-based surveillance systems have been developed by research groups from academia and industry alike. In broad terms, advanced video-based surveillance could be described as intelligent video processing designed to assist security personnel by providing reliable real-time alerts and to support efficient video analysis for forensics investigations.

The aim of this special issue is to present recent theoretical and practical advances in the broad area of video processing for advanced surveillance. Topics of interest include, but are not limited to:

- Change and motion detection
- Single- and multitarget tracking
- Single- and multicamera tracking
- Video analytics
- Motion trajectory analysis
- Behaviour analysis and event detection
- Activity analysis and monitoring
- Pattern recognition and machine learning for surveillance
- Automatic video annotation and summarization
- Biometrics for surveillance (e.g., face, iris, gait, etc.)
- Privacy and surveillance
- Performance evaluation of surveillance systems
- Hardware and software architectures for advanced surveillance

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Special Issue on

Opportunistic and Delay Tolerant Networks

CALL FOR PAPERS

Wireless and mobile computing advanced significantly in the last decade. This opens new ways for mobile users to get connected to each other. In particular, users have more and more the possibility to spontaneously establish direct links between them without the support of a preexisting infrastructure. Due to the natural mobility of the users, it is very likely that the resulting topology be intermittently connected. This leads to two main issues. First, nodes must find a way to benefit from contact opportunities whenever possible. Second, given that intercontact times are unpredictable, applications must better tolerate delays.

In practice, opportunistic and delay-tolerant networks are much closer to real situations than the legacy mobile ad hoc networks. But this comes at the cost of more challenging problems, as traditional communication architectures, commonly based on the end-to-end principle, are not adapted to intermittently connected scenarios. Although the research community has provided major contributions in this area, there are still a lot of questions that remain unanswered. These questions are both related to the understanding of the fundamental aspects of such networks and how to make them become a reality and coexist with other networks.

The goal of the proposed special issue is to help filling this gap by presenting contributions ranging from theoretical foundations to practical experiences in opportunistic and delay-tolerant networks. As we intend to focus on both theoretical and practical aspects of these networks, papers presenting insights covering all levels of the communication architecture will be welcome. Topics of interest include, but are not limited to:

- Architectural principles of opportunistic and delay-tolerant networks.
- Mathematical foundations of challenged networks.
- Participatory and opportunistic sensor networks.
- Tools and techniques for designing, analyzing, and building opportunistic networks.
- Experimental deployments and measurement campaigns.
- Investigation of new interaction patterns among users.

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Special Issue on

Security and Resilience for Smart Devices and Applications

CALL FOR PAPERS

It is widely argued that the increased requirements on ubiquitous computing and network access led us to the era of smart devices and wireless communications. The number of mobile phones, PDAs, NFC, RFID, smart card tokens, and other computing and portable devices requiring wireless network access has superseded that of wired ones.

Wireless communications and smart devices provide many benefits such as mobility, portability and flexibility, increased productivity, and lower installation and maintenance costs. At the same time futurists are speculating about a world of ubiquitous computing and ambient intelligent, in which countless invisible sensors and actuators will communicate with each other, imminently taking care of our needs and wishes.

Depending on their specific underlying operational characteristics and deployment environment, these devices have specific platform, application, and communication requirements, and they may be routinely used by millions of users and for a variety of applications. These applications include a myriad of deployment scenarios including WLAN accessibility in order to check email and obtain access to the internet or other networks, buildings and public transport networks, or even engaging into financial transactions with banks or other individuals. As the technologies of next generation wireless networks and smart devices are emerging, security has become a primary concern, in order to ensure dependable, secure communications and services to the end user.

This special issue on security of next generation smart devices will present current research focusing on security-related protocols and applications, secure architecture and frameworks, along with new theories and methodologies for secure next generation wireless networks and respective smart devices. We will welcome contributions from the academic, industrial, research, and development communities that can demonstrate particular advances into the aforementioned proposals and technologies.

Areas of interest for this special issue include, but not limited, the following topics:

- Smart devices: mobile phones, personal assistant devices (PDAs), radio frequency identification devices (RFIDs), near-field-communication (NFC), portable computing devices, contact and contactless smart card, wireless sensor nodes (WSNs), trusted platform modules (TPMs)

- Smart devices applications: biometrics, national ID and passports, health care, pay TV, physical access control, Internet of things, public transport, mobile communications, new applications
- Smart devices networks: mobile ad hoc networks, wireless mesh networks, 3G/4G mobile cellular systems, delay-tolerant networks, domestic networks, sensor networks, vehicular networks

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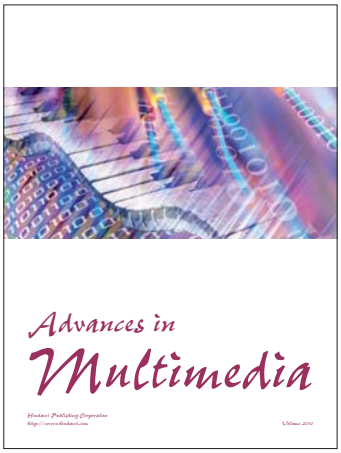
Advances in Multimedia

http://www.hindawi.com/journals/am/

Aims and Scope

Advances in Multimedia is aimed at presenting comprehensive coverage of the field of multimedia. The journal covers research and developments in multimedia technology and applications, including compression, storage, networking, communication, retrieval, algorithms, architectures, software design, circuits, multimedia signal processing, and multimodality devices and systems. Types of multimedia signals involved include audio, speech, video, image, graphics, geophysical, musical, sonar, radar, and medical signals.



Manuscript Submission

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We are committed to keeping the publication speed of the journal as fast as possible, while at the same time ensuring a thorough peer-review process. In order to ensure the fastest possible publication speed following the acceptance of a manuscript, once an article is accepted we make the author's version immediately available online. Then, in an average of 60 days, we publish the final edited version of the paper. Following an article-by-article schedule rather than an issue-by-issue schedule allows for a much faster publication speed, since articles are not delayed until an entire issue has been completed.

International Editorial Board

The journal has a distinguished Editorial Board with extensive academic qualifications, which ensures that the journal maintains high scientific standards and has broad international coverage.

Hindawi

Computational Intelligence & Neuroscience

http://www.hindawi.com/journals/cin/

Aims and Scope

Computational Intelligence and Neuroscience is a forum for the publication of research in the interdisciplinary field of neural computing, neural engineering, and artificial intelligence, where neuroscientists, cognitive scientists, engineers, psychologists, physicists, computer scientists, and artificial intelligence investigators among others can publish their work in one periodical that bridges the gap between neuroscience, artificial intelligence, and engineering. The journal provides research and review papers at an interdisciplinary level, with the field of intelligent systems for computational neuroscience as its focus.

Manuscript Submission

Manuscripts are invited and should be submitted by one of the authors of the manuscript through the online Manuscript Tracking System located at http://mts.hindawi.com.

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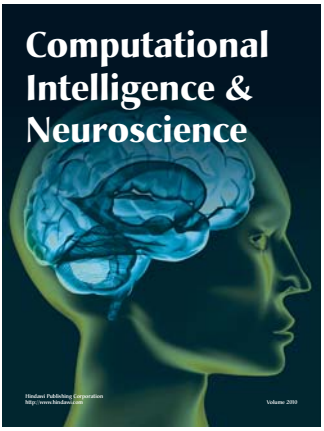

Publication Speed

In order to ensure the fastest possible publication speed following the acceptance of a manuscript, once an article is accepted we make the author's version immediately available online. Then, in an average of 60 days, we publish the final edited version of the paper. Following an article-by-article schedule rather than an issue-by-issue schedule allows for a much faster publication speed, since articles are not delayed until an entire issue has been completed.

International Editorial Board

The journal has a distinguished Editorial Board with extensive academic qualifications, which ensures that the journal maintains high scientific standards and has broad international coverage.

Aims and Scope

The aim of the EURASIP Journal on Advances in Signal Processing is to highlight the theoretical and practical aspects of signal processing in new and emerging technologies. Application areas include (but are not limited to) communications, networking, sensors and actuators, radar and sonar, medical imaging, biomedical applications, remote sensing, consumer electronics, computer vision, pattern recognition, robotics, fiber optic sensing/transducers, industrial automation, transportation, stock market and financial analysis, seismography, and avionics.

Indexing/Abstracting

In order to provide the maximum exposure for all published articles, the EURASIP Journal on Advances in Signal Processing is covered by many leading abstracting and indexing databases.

Manuscript Submission

Manuscripts are invited and should be submitted by one of the authors of the manuscript through the online Manuscript Tracking System located at http://mts.hindawi.com.

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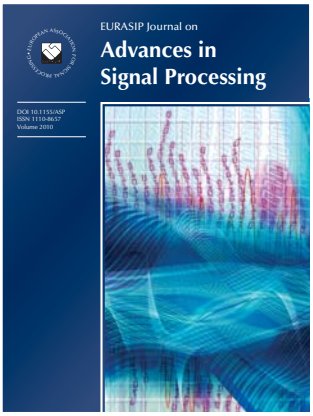


Publication Speed

We are committed to keeping the publication speed of the journal as fast as possible, while at the same time ensuring a thorough peer-review process. In order to ensure the fastest possible publication speed following the acceptance of a manuscript, once an article is accepted we make the author's version immediately available online. Then, in an average of 60 days, we publish the final edited version of the paper. Following an article-by-article schedule rather than an issue-by-issue schedule allows for a much faster publication speed, since articles are not delayed until an entire issue has been completed.

Hindawi

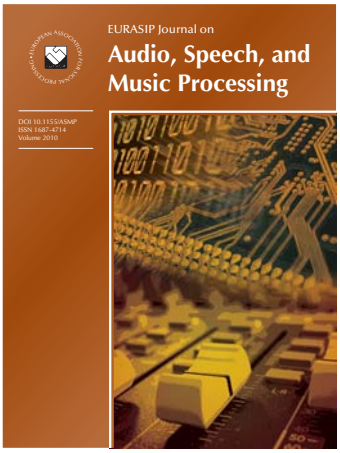
EURASIP Journal on

Audio, Speech, and Music Processing

http://www.hindawi.com/journals/asmp/

Aims and Scope

EURASIP Journal on Audio, Speech, and Music Processing is a peer-reviewed, open access journal, which aims at bringing together researchers, scientists, and engineers working on the theory and applications of the processing of various audio signals, with a specific focus on speech and music.



The journal is dedicated to original research work, but also allows tutorial and review articles. Articles deal with both theoretical and practical aspects of audio, speech, and music processing.

Manuscript Submission

Manuscripts are invited and should be submitted by one of the authors of the manuscript through the online Manuscript Tracking System which is located at http://mts.hindawi.com.

Open Access

EURASIP Journal on Audio, Speech, and Music Processing, as an open access journal, enables immediate, worldwide, barrier-free online access to the full text of published research articles for all interested readers. Accepted articles are released under the "Creative Commons Attribution License," by which the author remains the copyright holder and permits the unrestricted use, distribution, and reproduction of the article in any medium, provided the original work is properly cited.

Publication Speed

We are committed to keeping the publication speed of the journal as fast as possible, while at the same time ensuring a thorough peer-review process. In order to ensure the fastest possible publication speed following the acceptance of a manuscript, once an article is accepted we make the author's version immediately available online. Then, in an average of 60 days, we publish the final edited version of the paper. Following an article-by-article schedule rather than an issue-by-issue schedule allows for a much faster publication speed, since articles are not delayed until an entire issue has been completed.

Hindawi

EURASIP Journal on

Bioinformatics and Systems Biology

http://www.hindawi.com/journals/bsb/

Aims and Scope

The overall aim of EURASIP Journal on Bioinformatics and Systems Biology is to publish research results related to signal processing and bioinformatics theories and techniques relevant to a wide area of applications into the core new disciplines of genomics, proteomics, and systems biology.

The journal is intended to offer a common platform for scientists from several areas including signal processing, bioinformatics, statistics, biology, and medicine, who are interested in the development of algorithmic, mathematical, statistical, modeling, simulation, data mining, and computational techniques, as demanded by various applications in genomics, proteomics, system biology, and more general in health and medicine.

Manuscript Submission

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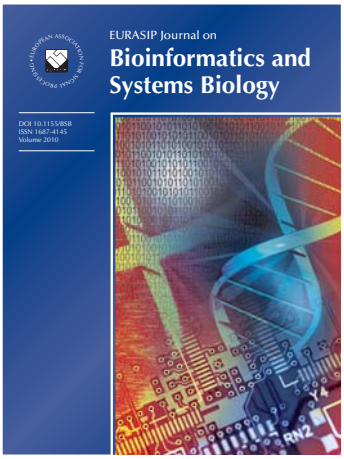

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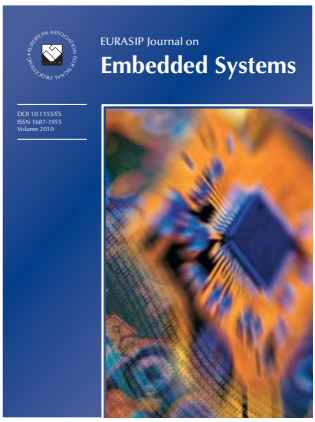
EURASIP Journal on Embedded Systems

http://www.hindawi.com/journals/es/

Aims and Scope

EURASIP Journal on Embedded Systems is a peer-reviewed open access journal that serves the large community of researchers and professional engineers who deal with the theory and practice of embedded systems, including complex homogeneous and heterogeneous embedded systems, specification languages and tools for embedded systems, modeling and verification techniques, hardware/software tradeoffs and codesign, new design flows, design methodologies and synthesis methods, platform-based design, component-based design, adaptation of signal processing algorithms to limited implementation resources, rapid prototyping, computing structures and architectures for complex embedded systems, real-time operating systems, methods and techniques for the design of low-power systems, interfacing with the real world, and novel application case studies and experiences.



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Hindawi

EURASIP Journal on Image and Video Processing

http://www.hindawi.com/journals/ivp/

Aims and Scope

EURASIP Journal on Image and Video Processing is a peer-reviewed, open access journal, intended for researchers from both academia and industry, who are active in the multidisciplinary field of image and video processing. The scope of the journal covers all theoretical and practical aspects of the domain, from basic research to the development of applications.

Contributed articles on image and video processing may be focused on specific techniques, on diverse functionalities and services, within the context of various activity sectors (e.g., multimedia, medical, aerial, robotics, security, communications, and arts), or on employing diverse data formats.

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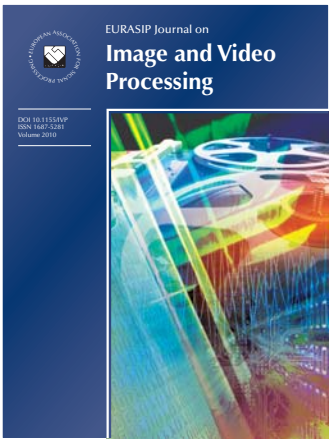

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International Editorial Board

The journal has a distinguished Editorial Board with extensive academic qualifications, which ensures that the journal maintains high scientific standards and has broad international coverage.

Hindawi

EURASIP Journal on Information Security

http://www.hindawi.com/journals/is/

Aims and Scope

The overall goal of the EURASIP Journal on Information Security is to bring together researchers and practitioners dealing with the general field of information security with a particular emphasis on the use of signal processing tools to enable the security of digital contents. As such, it addresses any work whereby security primitives and multimedia signal processing are used together to ensure the secure access to the data. Enabling technologies include watermarking, data hiding, steganography and steganalysis, joint signal processing and encryption, perceptual hashing, identification, biometrics, fingerprinting, and digital forensics.

Manuscript Submission

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Open Access

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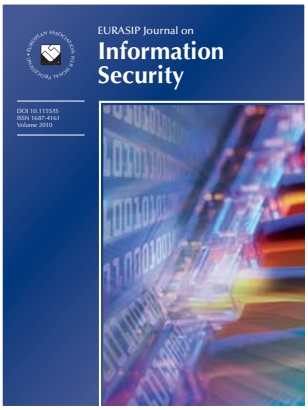

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Hindawi

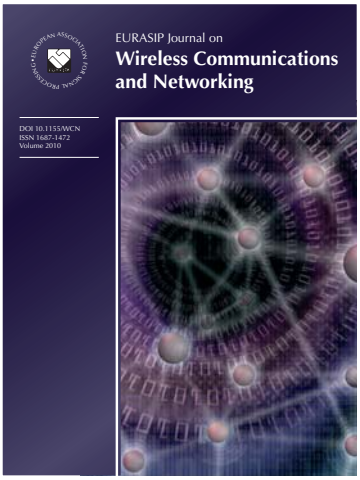
EURASIP Journal on

Wireless Communications and Networking

http://www.hindawi.com/journals/wcn/

Aims and Scope

The overall aim of the EURASIP Journal on Wireless Communications and Networking is to bring together science and applications of wireless communications and networking technologies, with emphasis on signal processing techniques and tools. Subject areas include antenna systems and design, channel modeling and propagation, coding for wireless systems, multiuser and multiple access schemes, optical wireless communications, resource allocation over wireless networks, security, authentication, and cryptography for wireless networks, signal processing techniques and tools, software and cognitive radio, wireless traffic and routing, ultra-wideband systems, vehicular networks, wireless multimedia communication, wireless sensor networks, and wireless system architectures and applications.



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Open Access

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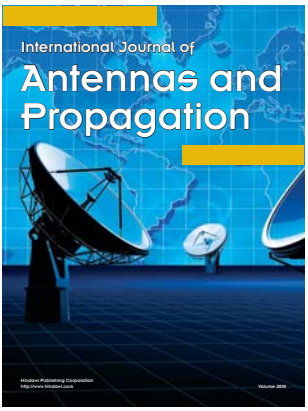
Hindawi

International Journal of Antennas and Propagation

http://www.hindawi.com/journals/ijap/



Aims and Scope

The overall aim of the International Journal of Antennas and Propagation is to explore emerging concepts and applications in antennas and propagation. The journal focuses on the physical link from antenna to antenna including antenna hardware and associated electronics, the nature and impact of propagation channels and measurement, prediction, and simulation methods for evaluating or designing antennas or the channel. The journal is directed at both practicing engineers and academic researchers and will highlight new ideas and challenges in antennas and propagation for both application development and basic research.

Manuscript Submission

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International Editorial Board

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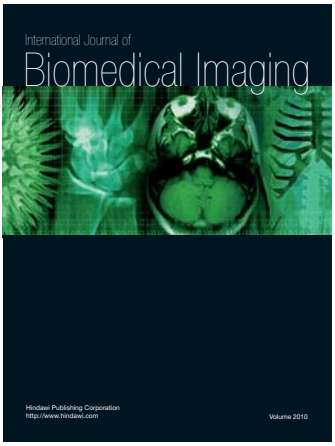
Hindawi

International Journal of Biomedical Imaging

http://www.hindawi.com/journals/ijbi/

Aims and Scope

The overall goal of the International Journal of Biomedical Imaging is to promote the research and development of biomedical imaging by publishing high-quality research articles and reviews in this rapidly growing, interdisciplinary field. Generally speaking, the scope of the journal covers data acquisition, image reconstruction, and image analysis, involving theories, methods, systems, and applications.



Indexing/Abstracting

In order to provide the maximum exposure for all published articles, International Journal of Biomedical Imaging is covered by many leading abstracting and indexing databases.

Manuscript Submission

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Hindawi

International Journal of

Digital Multimedia Broadcasting

http://www.hindawi.com/journals/ijdmb/

Aims and Scope

International Journal of Digital Multimedia Broadcasting aims to provide a high-quality and timely forum for engineers, researchers, and educators whose interests are in digital multimedia broadcasting to learn recent developments, to share related challenges, to compare multistandards, and further to design new and improved systems.

Subject areas include, but are not limited to:

- Multimedia broadcasting overall system and standardization, multimedia signal compression, and coding for broadcasting
- Multimedia streaming and control, IPTV with broadcasting, multimedia content services, and digital rights management over broadcasting
- Modulation and demodulation
- Channel estimation and equalization
- VLSI design and system-on-chip implementation for multimedia broadcasting reception
- Cross-layer analysis and integration, single-chip solution, and power and spectral efficiency
- Antenna and propagation for multimedia transmission and reception
- Multistandards compatibility and multisystems interoperability
- Multibands frequency interface issues, spectrum management, and usage
- Filed-trials and testing analyses
- Quality of service and quality of experience in multimedia broadcasting

Open Access

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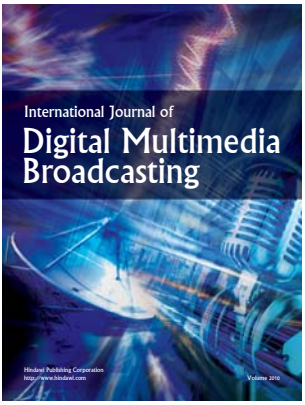

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Hindawi

International Journal of
Navigation and Observation

http://www.hindawi.com/journals/ijno/

Aims and Scope

The overall aim of the International Journal of Navigation and Observation is to explore emerging concepts and applications in navigation, positioning, earth observation, and related fields. The journal is directed at both practicing engineers as well as academic researchers. It will highlight new ideas and challenges in both application development and basic research, thus seeking to bridge the gap between innovation and practical implementation. Authors of manuscripts with novel contributions to the theory and/or the practice of navigation, positioning, and earth observation are encouraged to submit their contributions for consideration.

Manuscript Submission

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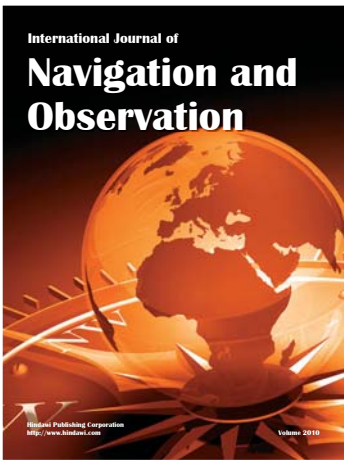

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Hindawi

International Journal of

Reconfigurable Computing

http://www.hindawi.com/journals/ijrc/

Aims and Scope

The aim of the International Journal of Reconfigurable Computing is to serve the large community of researchers and professional engineers working on theoretical and practical aspects of reconfigurable computing. The journal seeks to promote the use of reconfigurable computing for research, education, and applications. Original full and short papers on all aspects of reconfigurable computing, from hardware architectures and devices to custom computers and high performance systems, are encouraged for submission.

All aspects of reconfigurable computing are considered. Since the entire field is very dynamic, areas of the interest include but are not limited to:

- Models, methods, tools, and architectures for reconfigurable computing
- Compilation, simulation, debugging, synthesis, verification, and test of reconfigurable systems
- Field programmable gate arrays and other reconfigurable technologies
- Self adaptation and dynamic reconfiguration
- Evolvable hardware and adaptive computing
- Algorithms implemented on reconfigurable hardware
- Hardware/software codesign and cosimulation with reconfigurable hardware
- High performance reconfigurable computing
- Reconfigurable computing education

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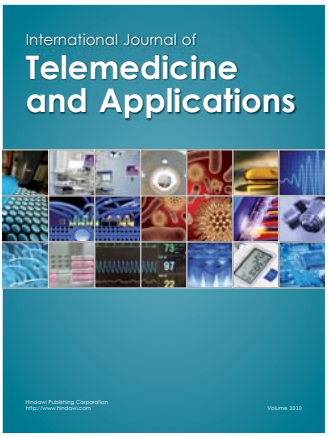
International Journal of

Telemedicine and Applications

http://www.hindawi.com/journals/ijta/

Aims and Scope

The overall aim of the International Journal of Telemedicine and Applications is to bring together science and applications of medical practice and medical care at a distance as well as their supporting technologies such as computing, communications, and networking technologies with emphasis on telemedicine techniques and telemedicine applications. Telemedicine is an information technology that enables doctors to perform medical consultations, diagnoses, and treatments, as well as medical education, away from patients. International Journal of Telemedicine and Applications will highlight the continued growth and new challenges in telemedicine, applications, and their supporting technologies, for both application development and basic research.



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Hindawi

Journal of

Computer Systems, Networks, and Communications

http://www.hindawi.com/journals/jcsnc/

Aims and Scope

Journal of Computer Systems, Networks, and Communications is dedicated to report the state-of-the-art research in the most important areas of information technology that are computer systems, networks, and communications.

Subject areas covered by the journal include (but are not limited to):

- Cognitive, smart and software radios, computer and network software/storage
- Computer architecture and telecommunications, digital signal processing, multimedia and DSL-based applications, information theory, information systems, integrated circuitry and voice applications
- Intelligent computer, network systems, Internet and web technologies, mobile and ubiquitous computing, network coding/cooperation, optical systems, communications and networking
- PAN/LAN/MAN/WAN and high speed packet data access
- Peer-to-peer, QoS and routing & switching, satellite and mobile cellular communications, security, privacy and encryption
- Sensor, ad-hoc and mesh networks and vehicle-to-vehicle communications
- Wireless communications and networking

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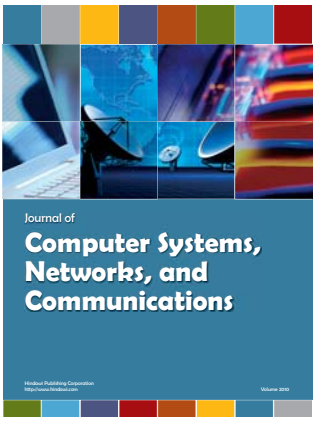

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Hindawi

VLSI Design

http://www.hindawi.com/journals/vlsi/

Aims and Scope

VLSI Design is a peer-reviewed, open access journal, which presents state-of-the-art papers in VLSI design, computer-aided design, design analysis, design implementation, simulation, and testing. Topics relating to both theory and applications are discussed. The journal's scope also includes papers that address technical trends, pressing issues, and educational aspects in VLSI Design.

The journal provides a dynamic, high-quality, international forum for original papers and tutorials by academic, industrial, and other scholarly contributors in VLSI Design.

Indexing/Abstracting

In order to provide the maximum exposure for all published articles, VLSI Design is covered by many leading abstracting and indexing databases.

Manuscript Submission

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Open Access

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Speech Communication	☐ 106€	☐ 95€	☐ 1005€
Image Communication	☐ 106€	☐ 92€	☐ 855€

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