Biennial since 1998

CSNDSP 2022

13th IEEE/IET International Symposium on Communication Systems, Networks and Digital Signal Processing

20 – 22 July 2022, Porto, Portugal

Book of Abstracts

instituto de telecomunicações

bcs The Chartered Institute for IT

IEEE PORTUGAL SECTION

IET The Institution of Engineering and Technology

IEEE

IEEE ComSoc Portugal Chapter

This is the short version of the booklet for web use.
Full papers with all authors, references, and figures can be found at:
https://csndsp2022.av.it.pt/

Contents

About

CSNDSP

CSNDSP is celebrating 25 years! It has been running biennial since 1998 growing in size and success and normally attract about 200 delegates from around the world. It has been recognised as an international forum to present and exchange research findings and discuss future research topics in the fields of communication systems, communications networks, digital signal processing and other related areas. CSNDSP offers the opportunities for researchers to participate in organising workshops, tutorials, and open discussions in upcoming research topics. Papers accepted for presentation are published in IEEEXplore while selected papers are published in prestigious sponsoring journals.

This year, CSNDSP 2022 is hosted in the world heritage city of Porto, Portugal. Participants will have the opportunity to explore Porto's landscapes, its alleyways full of history and nostalgia. It will be an excellent opportunity to taste local gastronomy and enjoy the famous Porto wines.

Organization

Steering Committee

Zabih Ghassemlooy	Steering Committee Chair
M D Logothetis	Chair of the Special Sessions and Colloquiums
Stanislav Zvanovec	Chair of the Keynote Speakers
Wai Pang Ng	Chair of the Paper Review/Selections
Mohammad Ali Khalighi	Chair of Travel Grants and Best Paper Prizes
Anna Maria Vegni	Chair of Special Issues of future journals
A C Boucouvalas	'in memory'

Local Organizing Committee

Luís Nero Alves	Chair of the local organizing committee
Adão Silva	Vice-Chair for Technical Program
João Paulo Barraca	Vice-Chair for Communications
Rui Dinis	Technical Program
Ana Aguiar	Technical Program
Maria do Carmo Medeiros	Technical Program
Pedro Fonseca	Publications and Sponsorship
Rafael Caldeirinha	Publications and Sponsorship
Mónica Figueiredo	Publicity and Communications
Rui Prior	Logistics
Pedro Brandão	Logistics
Joaquin Perez	Logistics
Sérgio Crisostomo	Logistics

Technical Committee

A A Tahat	Princess Sumaya University for Tech., Jordan
A Chydzyński	Polish Academy of Science, Poland
A Constantinides	Imperial College, UK
A Inoue	Chiba Instut. Of Tech., Japan
A Kaloxylos	University Of Peloponnese, Greece
Alexandre Pohl	Univ, Tecn. Federal Paraná, Brasil
Alex Shenfield	Manchester Met. University, UK
A Mohammed	Blekinge Inst. of Technology, Sweden
Andrew Weightman	University of Manchester, UK
A Vinel	Russian Academy of Sciences, Russia
C G Lee	Chosun University, China
Danielle George	University of Manchester, UK
D Benhaddou	University of Houston, USA
D Careglio	UP Catalunya, Spain
D Dimitrov	Technical University of Sofia, Bulgaria
D Ka Chun So	University of Manchester, UK
E Alsusa	University of Manchester, UK
E Gaikoumidis	Aston University, UK
Faruk Ozek	Ankara University, Turkey
F Liu	University Twent, The Netherlands
F Ramos	UP Valencia, Spain
Frank Deicke	Fraunhofer Inst. for Photonic Microsystems, Germany
F S Marzano	University of L'Aquila, Italy
G Barzdins	University of Latvia, Riga, Latvia
G Kandus	IJS Ljubljana, Slovenia
H Castel	Inst. Natio. D. Télécom., France
H Takruri	University of Salford, UK
I Darwazeh	University College, London, UK
I Frigyes	BME, Hungary
I Moscholios	University of Peloponnese, Greece
I Soto	Santiago University, Chile
I Tomkos	AIT, Greece
J Armestrong	Monash University, Australia
J Cheng	The University of British Columbia, Canada
J Haase	Vienna University of Technology, Austria
J Hrad	Czech Technical University in Prague
J-P Barbot	ENSEA, France
J Rodrigues	Agnel Technical Education Complex, India
J Zhao	Tyndall National Institute, Ireland
K Yousef	Chamran University Iran
L Chao	Hong Kong Polytechnic University, China
L Stergioulas	Brunel Uni., UK
L Yi	Shanghai Jiao Tong University, China
M AL-Qutayri	KUSTAR, UAE
Mark Leeson	Universityof Warwick, UK
Mathew Southgate	MMU, UK

M Connelly	University of Limerick, Ireland
M Gebhart	NXP, Gratkorn, Austria
M Ghavami	London South Bank University, UK
M Głąbowski	Poznan University of Tech., Poland
M Jubran	Birzeit University, Palestine
M Matijasevic	FER Zagreb, Croatia
M Matsumoto	Waseda University, Japan
M N Zervas	Southampton University, UK
Nader Anani	Manchester Met. University, UK
N Bizon	University of Pitesti, Romania
N Calabretta	Eindhoven University of Tech., Netherland
Nick Bowring	MMU, UK
O Al-kharji	TRA, UAE
Paulo Monteiro	University Aveiro, Portugal
P Ball	Oxford Brookes University, UK
P Chatzimisios	International Hellenic Unive., Greece
P Pacyna	University of Science and Tech., Poland
P Remlein	Poznan University of Technology, Poland
P Saengudomlert	Bangkok University, Thailand
P Truchly	Slovak University of Tech., Slovakia
P Xiao	Queen's University, Belfast, UK
P Zwierzykowski	Poznan University of Tech., Poland
R G Tosibeleffi	Ministero Sviluppo Economico, Italy
R J Green	University of Warwick, UK
R Ngah	Tech. University of Malaysia, Malaysia
R Penty	Cambridge University, UK
R Qahwaji	Bradford University, UK
R Saatchi	Sheffield Hallam University, UK
R Stewart	AIT, Iraland
Saeed Olyaee	Rajaee TT University University, Iran
Saleh Al-Araji	KUSTAR, UAE
S Aleksic	TU Wien, Austria
S Gao	University of Kent, UK
S Harmer	MMU, UK
Simon Maskel	University of Liverpool, UK
S K Liaw	Nat. Taiwan University of Sc. and Tech., Taiwan
S M Sajid	University of Eng.&Tech., Lahore, Pakistan
S Papaharalabos	Natio. Observatory of Athens, Greece
S Rajbhandari	Bangor University, UK
S Shioda	Chiba University, Japan
S Sygletos	University of Karlsruhe, Germany
T Kamalakis	University of Athens, Greece
Tony Brown	University of Manchester, UK
U Speidel	University of Auckland, New Zealand
V Ahmadi	Tarbiat Modras University, Iran
V Vitsas	International Hellenic University, Greece
W Gappmair	Graz University of Technology, Austria
W-K Ling	Guangdong University of Technology, China
W O Popoola	Glasgow Caledonian University, UK

W Pribyl	TU Graz, Austria
X Tang	Tsinghua University, Beijing, China
Y Viniotis	University Raleigh, USA
Z Zhu	University of Science and Technology, China

Timetable

	Wednesday, July 20			
8h00	Registration (Foyer)			
	Opening Ceremony (Auditorium II)			
9h00	Plenary Talk 01: How Vehicular Networks can be used to improve the safety on roads: examples from a city-scale digital open laboratory, Susana Sargento (Auditorium II)			
10h00	OWC 01: Free Space Communications (Auditorium II)	OWC 02: Hybrid Communications System (Room A)	SatCom 01: Colloquium on Satellite and Space Communications (Room B)	FIBER 01: Colloquium on Optical Fiber Devices and Sensing Applications (Room C)
11h00	Coffee Break			
12h00	OWC 03: Optical Camera Communications (Auditorium II)	OWC 04: Modeling and Simulation (Room A)	SatCom 02: Colloquium on Satellite and Space Communications (Room B)	CSNDSP 01: PHY Wireless Communications (Room C)
13h00	Lunch Break (Fundação Dr. Cupertino Miranda Restaurant)			
14h00	Plenary Talk 02: Optical Transport Networks in the 5G Era, Paolo Monti (Auditorium II)			
15h00	OWC 05: Free Space Optical Communications (Auditorium II)	CSNDSP 02: Wireless Networks (Room A)	SS 05: Teletraffic Models, Traffic Engineering and Network Optimization (Room B)	FIBER 02: Colloquium on Optical Fiber Devices and Sensing Applications (Room C)
16h00	Coffee Break			
17h00	SS 01: Joint Radar and Communications for 6G Networks (Auditorium II)	SS 02: Advancements and Emerging Trends in Cybersecurity (Room A)	SS 03: Emerging Topics in 6G Communications (Room B)	SS 04: Machine Learning for Biomedical Applications (Room C)
18h00	SC + LOC Meeting (Auditorium II)			
19h00				
20h00	Welcome Reception (Casa dos Arcos)			
21h00				
22h00				

	Thursday, July 21			
8h00				
	Registration (Foyer)			
9h00	Plenary Talk 03: Guessing Random Additive Noise Decoding (GRAND) or how to stop worrying about error-correcting code design, Muriel Médard (Auditorium II)			
10h00	OWC 06: Applications (Auditorium II)	OWC 07: Modeling and Simulation (Room A)	FRONT-EDGE 01: New Edge Application Use Cases (Room B)	CSNDSP 03: Security and Privacy (Room C)
11h00	Coffee Break			
12h00	OWC 08: Optical Camera Communications (Auditorium II)	OWC 09: System Design (Room A)	FRONT-EDGE 02: DSP & Transmission in Edge/Access (Room B)	CSNDSP 04: Image Processing (Room C)
13h00	Lunch Break (Fundação Dr. Cupertino Miranda Restaurant)			
14h00	Plenary Talk 04: Multi-Mode MIMO Communications Beyond Beamforming, Emil Björnson (Auditorium II)			
15h00	OWC 10: Applications (Auditorium II)	CSNDSP 05: Signal Processing (Room A)	FRONT-EDGE 03: Enabling Technologies (Room B)	FIBER 03: Colloquium on Optical Fiber Devices and Sensing Applications (Room C)
16h00	Coffee Break			
17h00	FRONT-EDGE 04: Enabling Technologies (Auditorium II)	SS 06: Towards ML-Based Efficient and Secured 6G Networks (Room A)	SS 07: Massive MIMO and Millimeter-Wave Communications (Room B)	SS 08: UAV Communications: Energy Efficiency, Resource Management and Security (Room C)
18h00				
19h00	Taylors Cellar's Visit			
20h00	Gala Diner (Restaurant Barão de Fladgate)			
21h00				
22h00				

	Friday, July 22			
8h00				
	Registration (Foyer)			
9h00	Plenary Talk 05: Recent Advances in Machine Learning for Signal and Image Processing, Miguel Rodrigues (Auditorium II)			
10h00	OWC 11: Under Water Optical Wireless Communications (Auditorium II)	OWC 12: Positioning and Localization Systems (Room A)	FRONT-EDGE 05: Topologies, Networking, Traffic, Architectures (Room B)	
11h00	Coffee Break			
	OWC 13: System Design (Auditorium II)	FRONT-EDGE 06: Topologies, Networking, Traffic, Architectures (Room A)		
12h00				
13h00	Lunch Break (Fundação Dr. Cupertino Miranda Restaurant)			
14h00	Closing Ceremony (Auditorium II)			
15h00	Oporto Sight Seeing			
16h00				
17h00				
18h00				

Abstracts

Day 1 - 20 July 2022

Plenary Talk 01

Start: 09:00 End: 10:00
Location: Auditorium II
Session Chairs: *Pedro Fonseca, University of Aveiro and Anna Maria Vegni, Roma Tre University*

P How Vehicular Networks can be used to improve the safety on roads: examples from a city-scale digital open laboratory

Susana Sargento
Universidade de Aveiro

Abstract: The World Health Organization reports the continued growth of deaths in road accidents, which have reached 1.35 million people in 2016. Increasing the safety in roads requires the reduction of the number of accidents and the delay in the response time of an emergency vehicle. Smart cities contain new mechanisms to collect information regarding the traffic status, congestion places, or the speed of vehicles in real-time. The evolution of wireless communications, particularly Vehicular Ad-Hoc Networks (VANETs), allows vehicles to communicate with each other and with infrastructures located near the roads. The possible use of this type of communication and the consequent information exchange encouraged governments, the automobile industry, and the academy to invest in research projects around VANETs and Intelligent Transport Systems (ITSs). Those projects have as their primary goal to improve the road safety and vehicular traffic efficiency. Beyond the communication information, mobility sensors such as Lidars, RADARs, video cameras and traffic counters in the roads, are able to get mobility information in specific areas of the city, which complements the communication data. In this talk we address the challenges of the vehicular communication in the roads to improve their safety, and include some examples that are being tested in real environments. We specifically

address examples from the Aveiro Tech City Living lab, the safety services it can support, and how the interaction with citizens has been achieved.

Session OWC 01 - Free Space Optical Communications

Start: 10:00 End: 11:00
Location: Auditorium II
Session Chair: *Zabih Ghassemlooy, Northumbria University*

1 Artificial Generation of Mie Scattering Conditions for FSO Fog Chambers

Hristo Ivanov, Erich Leitgeb

Abstract: Terrestrial Free Space Optical (FSO) systems aim to provide an ultra-broadband connectivity within core, metro and access networks. While FSO is considered as a promising solution that meets the data throughput demands of new 5G and Internet of Things (IoT) era, the adverse atmospheric effects and in particular Mie scattering (fog), impose significant risks for communication outage events. In order to foresee and evaluate those fog-related issues within an optical wireless link, the current paper reports on experimental setup utilizing artificial fog sources based on mixture of different highly purified glycols and water. As means of determining the approach feasibility, both atmospheric microphysics by means of empirical modified Gamma Particle Size Distribution (PSD) fog functions and Mie theory are used to estimate the artificially simulated Mie scattering attenuation of glycol-water fluids characterized by their complex refractive indices. The obtained results for moderate continental fog and different glycol concentration demonstrate 69.7 dB/km FSO losses at average which outcome coincides with a naturally occurred fog event. Moreover, all results are compared with analyzed PSDs obtained based on laser diffraction system for two types of fog machines that operate with the considered glycol-water fluids.

2 An Experimental Testbed for Implementation and Validation of Software Defined FSO Under Atmospheric Conditions Using USRPs

Zun Htay, Zabih Ghassemlooy, Stanislav Zvanovec, Mojtaba Mansour Abadi, Andrew Burton

Abstract: In this paper, we propose a proof of concept for the software defined-based free space optical communication (FSO) using GNU radio eco-system. We present a highly reconfigurable real-time FSO system to emulate the atmospheric conditions for the medium-to-long transmission range. Using an experimental testbed, we validate the proposed concept utilizing universal software radio peripherals. We show that, the software defined FSO system offers greater flexibility, less complexity, and provides real-time signal processing results without the need to change the architecture of the hardware and the physical link space. The system performance is evaluated in terms of the estimated bit error rate under fog and turbulence conditions for 200 m link span.

3 Enhancing Spectral Efficiency of Ground-To-HAP FSO System with Adaptive MASK in Presence of Beam-Wander and AoA Fluctuation

Nancy Alshaer, Tawfik Ismail, Salsabeel Adel

Abstract: High Altitude Platform Station or HAP is an indispensable component for the upcoming wireless communication technologies. This paper presents an evaluation of the performance of a Ground-to-HAP communication system using free-space optical (FSO) technology. The performance of the system is determined by three factors: channel state, pointing error, and angle-of-arrival (AoA) fluctuation. Accordingly, the modulated Gamma distribution is used as a channel modeling of the Ground-to-HAP uplink communication to analyze the effect of turbulence and beam wandering on the channel state. In this paper, a combined PDF of the uplink channel is driven considering atmospheric turbulence, beam wandering, pointing error, and link interruption due to AoA fluctuations. Furthermore, the performance of the system is presented in terms of average symbol error rate (ASER) as well as the outage probability for a signal modulated by using a Multi-Level (M-ary) ASK scheme. Finally, an ASER adaption is performed to maximize the number of bits transmitted per symbol period for different SNR values, enhancing spectral efficiency.

4 Aerosol Attenuation Model for High Altitude UAV-Based FSO Links

Mohammed Elamassie, Murat Uysal

Abstract: Free space optical (FSO) communication systems are greatly influenced by the atmospheric effect on beam propagation. This effect may differ from one wavelength to another. Therefore, the selection of wavelength for FSO systems may depend on weather conditions. For this reason, the choice of wavelength has been a subject of controversy among designers and users of commercial FSO systems, which operate, typically, in the wavelengths of 690, 780, 850, and 1550 nm. While several research works on FSO communication systems consider the effect of Fog, Fog may not a factor for FSO links between high altitude unmanned aerial vehicle (UAV). Actually, the suspended particles in the atmosphere, known as aerosols, that can be found at high altitudes in the atmosphere are important in such inter-UAV FSO links. In this paper, we consider Aerosol and conduct extensive simulations in MODTRAN® 6 to determine the extinction coefficient values over the wavelength from 350 nm to 1550 nm. Utilizing the MATLAB Non-linear curve fitting, we obtain a closed-form expressions for the Aerosol extinction coefficients.

Session OWC 02 - Hybrid Communications Systems

Start: 10:00 End: 11:00
Location: Room A
Session Chair: *Stanislav Zvanovec, Czech Technical University in Prague*

1 An Intelligent Clustering Algorithm Based on Hybrid RF/VLC Communication Model for VANET

Rongrong Yin, Sijia Liu, Hua-hua Zhu, Xiaohan Cui, Xudan Song, Xuyao Ma

Abstract: With the increasing density of vehicles and the increasing demand for high data rates, Visible Light Communication(VLC) has been added to the traditional VANET communication based on Radio Frequency (RF) as a new green communication technology. In order to improve the communication quality between vehicles, this paper presents a hybrid communication model of RF and VLC, and then proposes an intelligent cluster head(CH) selection algorithm based on reinforcement learning(RL). In this algorithm, the communication mode is judged and selected according to the relative position of the CH and its members, and the vehicles are divided into clusters by the relative position and the relative speed, and the total signal-to-noise ratio(SNR) in the cluster is taken as the reward to select the CH intelligently. Simulation results show that compared with the Stable Clustering Algorithm for vehicular ad hoc networks (SCalE), the proposed algorithm has higher SNR and lower power consumption.

2 Improved Bandwidth Performance of Hybrid Optical Wireless Communication for an Indoor IoT Environment

Shivani Rajendra Teli, Carlos Guerra-Yánez, Stanislav Zvanovec, Rafael Perez, Zabih Ghassemlooy

Abstract: In this paper, we propose the hybrid optical wireless communication system using a single light-emitting diode (LED) as a transmitter (Tx) as well as a photodiode and image sensor-based receivers (Rxs) for an indoor IoT environment. The proposed system utilizing a single LED offers simultaneously high- and low-speed transmission capabilities using visible light communication (VLC) and optical camera communication (OCC) links, respectively. The proposed scheme is intended to provide a versatile IoT environment by giving users the choice to switch between links based on device availability. By means of experimental implementation, we show that using a chip LED modulated with bipolar on-off keying modulation format and biased voltage levels improves signal transmission on both VLC and OCC links and thus the throughput of the system. Furthermore, we propose amplitude overlap AOL in the modulation format to improve the data throughput of VLC link. The results depict that error-free transmission is achieved for the VLC link at a data rate of up to 100 Mb/s which is double the 3-dB bandwidth of LED at AOL values of 0.3 and 0.5, and for the OCC link at a data rate of up to 2 kb/s at AOL values of 0 and 0.3.

3 Hybrid WDM POF-VLC Links for M-QAM Signal Transmission Based on Centralized Laser Diodes for Smart Factories

Juan A Apolo, Beatriz Ortega, Vicenc Almenar

Abstract: A centralized single source for hybrid fiber/wireless visible communication links is demonstrated employing off-the-shelf components. Experimental transmission of QPSK and M-QAM signals over wavelength-division-multiplexed (WDM) optical carriers emitted by two laser diodes in the visible spectrum leads to 6 Gb/s total bitrate. The system performance characterization in terms of SNR and EVM for different modulation formats and bandwidths paves the way for future deployment in industrial environments.

4 Massive Machine-Type Communications via Hybrid OWC/RF Networks

Tijana Devaja, Milica Petkovic, Andrea Munari, Federico Clazzer, Marko Beko, Dejan Vukobratović

Abstract: In this paper, we investigate the design of a novel hybrid optical wireless communication (OWC)/radio frequency (RF) solution suitable for massive machine-type communication (mMTC). The proposed scenario consists of a massive collection of indoor OWC-based small cells that connect low-cost Internet of Things (IoT) devices to the network infrastructure via an outdoor low-power wide-area network (LP WAN). We assume both indoor OWC and outdoor LP WAN parts of the mMTC system use slotted ALOHA as a random access mechanism. The main contribution of this paper is in derivation of expressions for the packet loss rate, which provide insights into the considered system design as a function of the indoor OWC and outdoor LP WAN system parameters.

Session SatCom 01 - Colloquium on Satellite and Space Communications

Start: 10:00 End: 11:00
Location: Room B
Session Chair: *Mojtaba Mansour Abadi, Northumbria University*

1 GPS Type Tracker Based on LoRa Transmission for MRC-100 3-PocketQube Student Satellite

Yasir Ahmed Idris Humad, Levente Dudás

Abstract: The usage of GPS type trackers has been one of the most promising subjects in the technical, social, and security areas during the last several years, and the industry of GPS manufacturers has been fast developing since then. Many GPS trackers experiments can be found in the Microwave Remote Sensing Laboratory at the Department of Broadband Infocommunications and Electromagnetic Theory at BME. The main aim of this paper was to investigate the strong basis and clear concept of using the 70 cm UHF (Ultra High Frequency) Band of the MRC-100 satellite's communication subsystem to send and receive NMEA data of GPS tracker information based on LoRa modulation received from the GPS Tracker on the ground surface. This will be the first 3-PQ satellite ($5 \times 5 \times 15$)cm in the world to contain this type of GPS tracker system.

2 Thermal Characterisation of the PRETTY Software-Defined Radio's Receiving Channels

Andreas Hörmer, Manuel Kubicka, Manuela Wenger

Abstract: The main payload of the PRETTY satellite is for passive reflectometry. For this purpose, a Software-Defined Radio receiver with two receive channels and a custom-built two patch antenna to correlate the direct GPS signals and the reflected signal from Earth are used. A thorough characterisation of the receive channels is of utmost importance to identify the sources of error, especially the temperature influence. In particular, the amplitude of the digital output signal and the phase shift between the two input receive channels are characterised over the operating temperature range. A conversion of the measurement points at discrete steps in temperature, internal LNA gain and sampling rate into dedicated formulas for continuous representation of the measured values is presented in the paper.

3 Low Complexity Subset Precoding for High Throughput Satellite Systems

Karin Plimon, Johannes Ebert, Harald Schlemmer, Alberto Mengali, Alberto Ginesi

Abstract: Precoding is a well-known method for interference mitigation that enables a high throughput satellite (HTS) multi-beam system to step up from traditional 4-coloring (FR-4) to a full frequency re-use (FR-1) but challenges the resources with high computational complexity. The calculation of the optimum precoding matrix and the number of complex multiplications are the two most challenging tasks in terms of computational complexity to accomplish when using this interference mitigation method. In this article, we tackle the first problem by utilizing a MMSE approach to determine the precoding matrix and focus instead on the latter. We propose a method to reduce the number of required complex multiplications in the gateway. The performance is evaluated based on different antenna patterns to identify crucial antenna pattern characteristics that define the number of required multiplications. The results indicate that the number of multiplications can be reduced depending on the present SNR and side lobe levels in the antenna pattern.

4 Subset Precoding and Tapering on Phased Arrays for High Throughput Satellite Systems

Karin Plimon, Johannes Ebert, Harald Schlemmer, Alberto Mengali, Alberto Ginesi

Abstract: Beamforming with phased arrays gained popularity for the design of new high throughput satellite (HTS) systems. In contrast to horn antenna arrays, they clearly offer more flexibility in space and provide the possibility to reduce interference while still aiming for full frequency re-use on ground. Often, tapering is also applied in these antennas to control the side lobe level. In this work, we apply the traditional beam precoding, as interference mitigation scheme on ground along with tapering in the forward link and determine possible options for the reduction of computational complexity by subset precoding. The performance evaluation is executed on a direct radiating array and an array fed reflector antenna. Apart from additive white Gaussian noise, also an adaptive coding and modulation margin and channel state information error are considered to create realistic channel conditions.

Session FIBER 01 - Colloquium on Optical Fiber Devices and Sensing Applications

Start: 10:00 End: 11:00
Location: Room C
Session Chair: *Serhiy Korposh, The University of Nottingham*

1 Two Broadband Polarization Beam Splitters Based on Hybrid Lattice and Asymmetrical Elliptic Dual-Core Photonic Crystal Fiber

Yunpeng Wei, Jinhui Yuan, Yuwei Qu, Binbin Yan, Kuiru Wang, Qiang Wu

Abstract: Two kinds of broadband polarization beam splitters (PBS) based on hybrid lattice structure and asymmetrical elliptic dual-core photonic crystal fiber (DC-PCF) are proposed. The bandwidth of the first PBS containing two kinds of air holes is 120 nm, while the propagation length is 3.2 mm. The bandwidth of the second structure containing three kinds of air holes is up to 340 nm, while the propagation length is 1.97 mm.

2 A Dual Hollow Core Negative Curvature Fiber Polarization Splitter with Ultra-Wide Bandwidth

Yueting Ni, Jinhui Yuan, Shi Qiu, Binbin Yan, Kuiru Wang, Qiang Wu

Abstract: A dual hollow core negative curvature fiber (NCF) with ultra-wide bandwidth is proposed.The splitter with the length of 6.45 cm can achieve an ultra-wide bandwidth of 400 nm, covering the O, E, S, C and L bands of communication bands.

3 A Surface Plasmon Resonance Sensor Based on D-Shaped Photonic Crystal Fiber for Low Refractive Index Detection

Xiaokai Liu, Jinhui Yuan, Yuwei Qu, Binbin Yan, Kuiru Wang, Qiang Wu

Abstract: A D-shaped single-core photonic crystal fiber optic sensor based on metal surface plasmon resonance (SPR) for measuring the low refractive index range is proposed. Detection of changes in the refractive index of the surrounding medium is achieved by plating silver (Ag) in an arc-shaped area. TiO2 is plated between the optical fiber surface and the silver layer to act as an adhesive. The sensor has a detection range of 1.19-1.31 and a maximum sensitivity of 11,000 nm/RIU. Therefore, the sensor can be used for organic chemical sensing, biological sensing, pharmaceutical sensing and other sensing applications where a wide range of spirit refractive index is required.

4 A Novel Refractive Index Sensor with an Open-Arch Channel Based on Surface Plasmon Resonance

Sainan Duan, Jinhui Yuan, Shi Qiu, Binbin Yan, Kuiru Wang, Qiang Wu

Abstract: A novel surface plasmon resonance sensor (SPR) with an open-arch channel based on D-shaped photonic crystal fiber (PCF) is designed for sensing refractive indexes. The refractive index sensor is sensitive up to 8800 nm/RIU in the refractive index range of 1.33 to 1.38.

Session OWC 03 - Optical Camera Communications

Start: 11:30 End: 12:30
Location: Auditorium II
Session Chair: *Wasiu O. Popoola, University of Edinburgh*

1 Experimental Demonstration of Non-Line-Of-Sight MIMO Optical Camera Communications with DBPWR Algorithm

Ningcong Jiang, Bangjiang Lin, Zabih Ghassemlooy, Tianming Huang, Zhuo Huang, Othman Isam Younus

Abstract: In this work, we propose a multiple inputs multiple outputs (MIMO) NLOS OCC system with multi-level pulse width modulation (MPWM) and difference-based pulse width recognition (DBPWR) schemes. The MPWM signals transmitted over NLOS link are separated using the DBPWR algorithm. Compared with the conventional threshold-based demodulation scheme, the proposed DBPWR scheme has lower complexity, higher reliability, and improved sampling frequency offset tolerance. A total data rate of 3.6 kb/s is experimentally demonstrated over more than 2 m NLOS link using the proposed MIMO OCC system, which is sufficient in many Internet of things applications.

2 Fractal Modulation Scheme for Optical Camera Communication

Antonio Mederos-Barrera, Carlos Guerra-Yánez, Cristo Jurado-Verdu, Victor Guerra, Jose Rabadan, Rafael Perez-Jimenez, Stanislav Zvanovec

Abstract: This paper proposes a novel spatial modulation scheme for optical camera communication based on the use of a fractal structure on the transmission. This system is able to send different amounts of data depending on the distance between the transmitter (Tx) and the receiver (Rx). Two simulation experiments were carried out to validate the proposed system. In the first experiment, the number of received bits was obtained as a function of the distance between the Tx and the Rx and compared to a theoretical expression that defines a lower bound. In the second experiment, the communication channel was tested by analyzing the behaviour of the bit error rate against the quantity of noise in the image using the peak signal-to-noise-ratio. It was found that for a PSNR value of 40 dB or more, the system is able to achieve a bit error rate below the forward error correction limit of 3.8 · 10-3. This architecture has potential applications in: hierarchization of data in vehicle-to-vehicle communications, distance multiplexing of data streams in cultural spaces, and security applications.

3 On-Demand Training of Deep Learning Equalizers for Rolling Shutter Optical Camera Communications

Cristo Jurado-Verdu, Victor Guerra, Carlos Guerra-Yánez, Jose Rabadan, Stanislav Zvanovec, Rafael Perez-Jimenez

Abstract: The camera's exposure time restricts the reception bandwidth in rolling shutter-based optical camera communication links. Short exposures are preferable for communications, but under these conditions, the camera produces dark images with impracticable light conditions for human or machine-supervised applications. Alternatively, deep learning equalization stages can mitigate the effects of increasing the exposure time. These equalizers are trained using synthetic images based on the camera's exposure time and row sampling frequency. If these parameters are unknown in advance, another artificial network is used to estimate them directly for the captured images, the estimator. This estimator is trained offline using a vast number (thousands) of representative cases. This work proposes to transfer the attained knowledge from the offline pretrained estimator to the equalizer by using transfer learning techniques. In this way, the equalizers' training time is significantly reduced (435 times compared to full training). Consequently, transfer learning enables equalizers' online and on-demand training at reception without interfering with the communications. Results reveal that the complete training requires using exclusively 250 synthetic images to guarantee a communication performance with a bit error rate below 10{−4} after the equalization.

4 Experimental Characterization of Sub-Pixel Underwater Optical Camera Communications

Behnaz Majlesein, Vicente Matus, Cristo Jurado-Verdu, Victor Guerra, Jose Rabadan, Julio Rufo

Abstract: Underwater Wireless Optical Communication (UWOC) is a promising technology to enable underwater communications for exploring and monitoring marine activities due to its high bandwidth and low latency. Furthermore, underwater optical camera communication (UOCC) takes advantage of light-emitting diodes (LEDs) and cameras already embedded in underwater devices (e.g., drones). In this work, a global shutter-based UOCC system is experimentally tested under a sub-pixel condition, where the dimensions of the LED in the image plane (in µm) are smaller than a single pixel. Although the LED projection dimensions are less than a single pixel, the incoming light irradiance spreads over a limited image sensor area. The results reveal that a 2 m link with a bit rate of 8 bps per channel (24 bps in total) can be attained using an RGB LED as a transmitter and a digital camera as a receiver by applying the point spread function for the demodulation. The validation of this system in sub-pixel conditions guarantees the operation of long-distance UOCC links, where extensive LED sources are perceived as single points in the image. In addition, as the LED dimensions in the image plane are significantly small, the camera can effectively accommodate several transmitters, increasing the link throughput considerably.

Session OWC 04 - Modeling and Simulation

Start: 11:30 End: 12:30
Location: Room A
Session Chair: *Valeria Loscrí, Inria Lille-Nord Europe*

1 Characterization of Materials for Optical Wireless Channel Simulation

Pierre Combeau, Lilian Aveneau, Pierre Le Gac, Ruqin Xiao

Abstract: This article proposes a new method to optically characterize materials, which is a very sensitive input data for realistic channel simulation based on Monte-Carlo Ray-Tracing algorithms. This original approach consists first in performing some optical power measurements based on a simple and low-cost experimental setup. These data then feed an optimization algorithm allowing to find the parameters of materials' reflection models that lead to simulation results fitting the measurements. As a proof of concept, our first results consider only simulated data as virtual measurement. They show that this approach gives very good agreement between estimated and actual optical characteristics of materials in canonical environment.

2 Secrecy Performance Improvement of a NOMA VLC Cellular Network with Artificial Noise

Fatemeh Bahadori, Seyed Mohammad Sajad Sadough, Zabih Ghassemlooy

Abstract: In this paper, we investigate the physical layer secrecy of a non-orthogonal multiple access (NOMA) VLC cellular network, where all users are moving based on the random way-point mobility model. To improve the secrecy performance of the proposed network, we consider the artificial light induced noise with the aim of disrupting the eavesdropper. More precisely, by considering the dynamic behavior of the network, we formulate the achievable secrecy rate of the legitimate users. To allocate power to legitimate users, we modify two well-known fixed power allocation and the gain ratio power allocation methods to improve the network sum secrecy rate. The numerical results indicate that the secrecy performance of the network is improved at least 2 dBs by employing the modified power allocation methods plus the artificial noise compared with the case of using the conventional version of the power allocation methods, which this value scales for higher transmit powers. Furthermore, the effect of half-power angle of the optical transmitter is considered with simulation results showing an optimum value for the half-power angle, which can vary depending on the considered scenario.

3 Modeling and Compensation of Nonlinear Distortion in Direct-Detection Optical Fast-OFDM Systems

Luis C. Vieira, Waseem Hazim Ozan Ozan, John Mitchell, Izzat Darwazeh

Abstract: Fast-OFDM based intensity-modulation and direct-detection (IM/DD) has been proposed for the deployment of cost-efficient optical access networks, due to simple implementation and high spectral efficiency. In this work, the generalized memory polynomial (GMP) is firstly applied to model the nonlinear characteristic of IM/DD Fast-OFDM links, including memory effects. After model validation using measured data of a 10 km single mode fiber link, the GMP is used for performance investigations of a combined clipping and digital post-distortion approach to optical Fast-OFDM, considering both 4PAM and 8PAM modulation formats and different number of Fast-OFDM subcarriers. This work firstly reports performance results of optical 8PAM-Fast-OFDM systems using 2PAM-based training signals for digital post-distortion and FFT-based channel estimation. Excellent performance improvements are achieved using the proposed distortion compensation scheme, relative to conventional system implementation.

4 PAPR Reduction in PAM-DMT Based WDM VLC

Hussien T. Alrakah, Tilahun Z. Gutema, Sinan Sinanovic, Wasiu O. Popoola

Abstract: Visible light communication (VLC) can achieve high data rate transmission with discrete multitone (DMT) systems. A DMT variant is pulse-amplitude-modulated discrete multitone modulation (PAM-DMT) which offers an energy-efficient modulation solution for VLC. However, similar to other DMT modulation techniques, PAM-DMT suffers from a high peak-to-average power ratio (PAPR). In this paper, the efficacy of pilot-assisted (PA) PAPR reduction system in PAM-DMT based VLC is demonstrated experimentally. Wavelength division multiplexing (WDM) is applied using three low-cost light emitting diodes (LEDs). The available modulation bandwidth of each light source is utilised by adaptive bit and power loading. PA PAM-DMT is compared in this work to PAM-DMT based on achievable data rate and Bit Error Rate (BER). The proposed system reduces the clipping noise and minimises the nonlinear distortion of the system by reducing the high PAPR of each wavelength. Thus, the PA PAM-DMT has achieved 8% higher data rate than the conventional PAM-DMT with no PAPR reduction.

Session SatCom 02 - Colloquium on Satellite and Space Communications

Start: 11:30 End: 12:30
Location: Room B
Session Chair: *Karin Plimon, Joanneum Research*

1 On the Secrecy Analysis of Satellite-Terrestrial Communication Link over Gamma-Shadowed Ricean Fading Channels

Jelena Anastasov, Predrag N. Ivanis, Jarosław Makal, Goran T Djordjevic, Dejan N Milic

Abstract: This paper deals with the physical layer security for the satellite-terrestrial communication system in the presence of an eavesdropper. In the analysis that follows, the satellite has no knowledge of the eavesdropper's channel state information referring to passive eavesdropping scenario. The main as well as the wiretap link are both characterized as gamma-shadowed Ricean fading channels. The analytical expressions for the secrecy outage probability and the probability of strictly positive secrecy capacity are derived. For the purpose of determining system's secrecy performance, the impact of fading/shadowing parameters and the average signal-to-noise ratios of the legitimate/illegitimate channels on aforementioned secrecy metrics is investigated. The results have shown that the nature of wireless communication channels can enhance system security at physical layer.

2 A Hybrid Free-Space Optical (FSO)/Radio Frequency (RF) Antenna for Satellite Applications

Mojtaba Mansour Abadi, Zabih Ghassemlooy

Abstract: Satellite units use reliable, an industrial de facto standard, and scientifically approved method of radio frequency (RF) data transfer. However, RF links are slow and require authorized permission for satellite and in-orbit applications. Recently, free-space optical (FSO) communication links are trending for satellite applications due to their huge potential for data transmission and low-cost implementation. Ideally, satellites would benefit from both RF and FSO technologies to ensure robustness and reliability. However, such a communication system requires the use of dedicated antenna and aperture for RF and FSO, respectively. The key challenges in the satellite transceiver systems are the size and mass. Therefore, having two separate units for each technology is not desirable. In this paper, we present a unique, compact, robust, and flexible design, which integrates optical wireless communication front-end aperture and radio antenna in a single module. We will present the design concept as well as RF and optics simulation results.

3 An OFDM-Based GEO-Satellite FSO Communications System Under Different Turbulent Regimes

Sina Ahadi, Gholamreza Baghersalimi

Abstract: In this paper, the performance of a geostationary (GEO) satellite free-space optical (FSO) communications system is investigated under different turbulent regimes. Such systems are extremely vulnerable to intrinsically random weather conditions, which in turn affect the transmitted signal both in amplitude and phase. In clear weather, optical links are mostly suffered from large-scale fading, while in moderate to strong turbulence due to heavy rain, foggy weather, or thick clouds, the optical link between the satellite and optical ground station (OGS) will affect the signal by large-scale and small-scale fading. This is due to the multipath propagation of the laser beam owing to pulse broadening, which leads to the bandwidth limitation of the link. To overcome this problem, we benefit from orthogonal frequency-division multiplexing (OFDM) scheme. Results demonstrate that the bit error rate (BER) performance decreases at higher bit rate and zenith angles. Also, we investigate the BER performance for three schemes including pulse amplitude modulation (PAM), phase-shift keying (PSK), and quadrature amplitude modulation (QAM). The results show that QAM has better BER performance in comparison with other schemes. In addition, the error vector magnitude (EVM) of the system is determined under different modulation schemes, various orders of QAM modulation.

4 A Gaussian Window for Interference Mitigation in Ka-Band Digital Beamforming Systems

Joana Santos Tavares, Helder Avelar, Henrique M Salgado, Luis M. Pessoa

Abstract: This paper proposes the use of a Gaussian window on the array factor as an interference mitigation method, that avoids the computational complexity of the MVDR method at the cost of a slight performance reduction. We show that by optimizing the parameters of the Gaussian window, it is possible to effectively mitigate the interfering signal if it is received within a certain angular range from the desired signal, while being still effective beyond that range. Finally, we show that the effectiveness of this approach is maintained across the full frequency reception range of the Ka-band, and confirm its validity using 8×8 and 16×16 array sizes.

Session CSNDSP 01 - PHY Wireless Communications

Start: 11:30 End: 12:15
Location: Room C
Session Chair: *Sérgio Crisóstomo, Universidade do Porto*

1 Energy and Spectrally Efficient Signalling for Next Generation IoT

Xinyue Liu, Izzat Darwazeh

Abstract: This work proposes an energy and spectrally efficient signalling technique for the next-generation internet of things (IoT). The signalling method employs the bandwidth compressed fast-orthogonal frequency division multiplexing (FOFDM) scheme with the single dimensional pulse amplitude modulation (PAM) as well as the frequency orthogonal filtering technique using Hilbert transform (HT) pair. The proposed HT-FOFDM system is designed and modelled based on the narrowband IoT (NB-IoT) specifications. To investigate the designed signalling method of different spectral efficiencies, we conducted simulations for HT-FOFDM with comparisons to single-carrier frequency division multiple access (SC-FDMA). We show that the proposed PAM modulated HT-FOFDM signalling increases the data rate effectively while maintaining reliable transmission within the same bandwidth of 180kHz. Comparative results of the bit error rate (BER) performance for HT-FOFDM in the additive white Gaussian noise (AWGN) channel and constellation diagrams of received noisy signals are presented. Furthermore, we show that HT-FOFDM with PAM modulation schemes comprehensively outperforms SC-FDMA that achieves the same spectral efficiency with significant power advantage.

2 Self-Optimizing Water-Filling Power Allocation: A Hybrid Fractional Frequency Reuse Way

Mingjun Ying, Shuyu Wang

Abstract: Due to the development of 5G networks, wireless data traffic is accelerating at an unprecedented rate. To increase a cellular network's spectral efficiency (SE), the fundamental approach is handling the power allocation (PA). First, we proposed a SE-optimal self-optimizing water-filling (SOWF) power allocation method that considers each user's channel SINR while determining the power allocation scheme for all of the OFDMA subchannels of each user. A near-optimal forward-looking water-filling (FLWF) method was then devised to decrease computing complexity. The proposed algorithm enhanced the SE for sFFR and SFR situations compared to the simultaneous water-filling (SWF), and the integer frequency reuse (IFR) approaches. We eventually validate that the proposed algorithms surpass conventional techniques in diverse conditions with Monte-Carlo simulations. The numerical results indicate that the SOWF + IFR3 achieves the maximum SE, which is 53% higher than the conventional IFR1 + IFR3 and 29% higher than the traditional SWF in the sFFR scenario. In addition, by implementing the proposed SOWF + IFR3 algorithm in the SFR scenario, the network capacity is comparable to

that of the FLWF + IFR3 and SWF + IFR3 algorithms in the sFFR situation.

3 WSN Sensor Node Antenna Performance Under Fallen Leaves

Tiago E. S. Oliveira, João Ricardo Reis, Rafael F. S. Caldeirinha

Abstract: In this paper, a study on the performance of a small sensor node antenna when covered with fallen leaves, is presented. Firstly, the Wireless Sensor Network (WSN) sensor node (SN) antenna considered for this work is being introduced. The antenna was already optimised in past author's work and is being used herein for a comparative analysis. Subsequent antenna performance analysis is carried out in four different scenarios considering the effects of the soil in the surroundings of the antenna and the partial coverage of the SN antenna by: pine tree leaves (i.e. pine needles) and Alfalfa tree leaves considering 10 and 75% of moisture content. Performance analysis is carried out via electromagnetic simulation using a full-wave electromagnetic solver (CST MWS) by means of antenna matching and radiation pattern characterisation. According to simulations, it is shown that the discarded leaves, negatively impact the performance of the antenna, generating shifts on the resonating frequency and typically reducing the overall gain of the antenna. The moisture content of the leaves also impact the antenna performance, specially for higher moisture content leaves,

Plenary Talk 02

Start: 14:00 End: 15:00
Location: Auditorium II
Session Chairs: *Monica Figueiredo, Polytechnic Institute of Leiria and Stanislav Zvanovec, Czech Technical University in Prague*

P Optical Transport Networks in the 5G Era

Paolo Monti
Chalmers University of Technology

Abstract: Optical technologies are the de-facto choice for transport networks in several 5G scenarios. The talk will address some open issues in the design and operation of optical transport networks. The topics will include but will not be limited to multi-technology network design and service provisioning, network slicing, network programmability, and network automation. Finally, the talk will conclude with an overview of the challenges we can expect when looking at beyond 5G scenarios.

Session OWC 05 - Free Space Optical Communications

Start: 15:00 End: 16:00
Location: Auditorium II
Session Chair: *Anna Maria Vegni, Roma Tre University*

1 Multidimensional LDPC-Coded Signal Transmission over TWDP Fading Channel

Goran T Djordjevic, Ivan B. Djordjevic

Abstract: In this paper, we analyze orbital angular momentum (OAM)-based signal transmission over front-haul/back-haul links in beyond 5G networks where bit-interleaved low-density parity-check (LDPC) coded modulation is used. The back-haul/front-haul links are modeled by recently proposed two waves with diffuse power (TWDP) fading model. We evaluate bit error rate performance in detecting multidimensional LDPC-coded signals transmitted over a TWDP channel. By applying Monte Carlo simulations, we investigate the effects of constellation dimensionality, number of points in constellation and number of iterations in decoder on BER performance of an LDPC code for different channel conditions. For given channel conditions and a fixed number of points in the constellation diagram, the simulation results aim to illustrate performance improvement by increasing the order of constellation dimensions from 2 to 4.

2 Investigation of RS-Code DP-QPSK Enabled FSO Communication Link Under Various Atmospheric Conditions

Dhiraj Kumar Patel, Abhilash Mandloi, Varun Srivastava, Abhishek Tripathi

Abstract: Modern free-space optical (FSO) communication have considered as solution for the scenarios like quick connectivity between two remote terrestrial links, radio wave pollution prohibited areas (for e.g. hospitals and industrial facilities). However, the reliability of the link are severely affected due to adverse atmospheric conditions due to turbulence and scattering media. This article presents the 112 Gbps data links using single channel dual-polarized (DP) quadrature phase shift keying (QPSK) modulation using Reed-Solomon (RS) codes as error correcting codes for improving the reliability of FSO communication links under fog affected atmospheric conditions. The coherent detection with digital signal processing (DSP) is considered for the demodulation of above optical received signal. Bit error rate (BER), received signal power, error vector magnitude (EVM) and coding gain were used to assess the system's performance. Based on the result outcomes, on comparing the link performance under moderate fog conditions $\approx$ 3 dB coding gain with $\approx$ 0.1 km link improvement achieved for the target log(BER) of -3.

3 Performance Analysis of M-Ary DPSK with SIMO in Ground-To-HAP FSO System in the Presence of Beam Wander and Scintillation

Salsabeel Adel, Nancy Alshaer, Tawfik Ismail

Abstract: Studying the performance of communication systems is essential to establish a reliable and stable link with an acceptable quality of service and minimum amount of resources. This paper evaluates the ground to HAP FSO link that uses the M-ary differential phase-shift keying (MDPSK) modulation technique in the presence of turbulence and beams wandering. The performance is analyzed by comparing the Average Symbol Error Rate (ASER) with an applicable threshold of 10-4. The results confirmed that, when limiting the transmitted power to 33 dBm, which is consistent with a practical perspective, the ASER is below the threshold only at a constellation size of 4. Therefore, a single input multiple output (SIMO) technique is introduced to improve the performance. The channel capacity is also shown to demonstrate the benefit of increasing the constellation size.

4 Software-Defined Networking for Free Space Optical Communication

Nithin Mohan, Zabih Ghassemlooy, Husain Rahman, Mohammad-Ali Khalighi

Abstract: Traditional IP networks lack the flexibility to respond to faults, network reconfiguration, and load changes in an ever-evolving digital society, which we call the Internet. To make matters worse, implementation of network policies requires configuration of each network device in which the control and data planes are coupled together using vendor specific commands. Software defined networking (SDN) is an emerging technology, which decouples the control plane from the data plane to provide flexibility in configuring/reconfiguring a network. In this manuscript, we present a SDN testbed using off-the-shelf components, write and deploy network applications onto the testbed, and demonstrate the functioning of the network application using a free space optical link.

Session CSNDSP 02 - Wireless Networks

Start: 15:00 End: 16:00
Location: Room A
Session Chair: *Pedro Fonseca, University of Aveiro*

1 Impact of Traffic Load and Spectral Occupancy on Gaussian Noise Models Performance for Multiband Networks

Pedro Venda, João Rebola, Luís Gonçalo Cancela

Abstract: In a network scenario, wavelength division-multiplexing channels are added and dropped leading to fluctuations on the network traffic loads along the optical path. In this work, a comparison between the optical signal-to-noise ratio (OSNR) predictions of the recently proposed closed-form generalized Gaussian noise (GGN) model and a closed-form Gaussian noise (GN) model that does not take into account the stimulated Raman scattering (SRS) is performed, for different network traffic loads and spectral occupancy over the entire C+L band. In all results obtained, the maximum difference between the OSNR predictions of GN (without SRS) and GGN models closed forms is below 0.7 dB at optimum OSNR and maximum C+L band occupancy, indicating that the GN-model can also be used in C+L band transmission. For channel launch powers higher than the optimum, the OSNR differences increase up to 3 dB, being the GN-model (without SRS) unsuitable to assess the network performance in such situations.

2 A Two-Stage Routing Algorithm for Time-Triggered Flows in Time Sensitive Networks

You-Ru Li, Pin-Chun Hou, Ting-Chao Hou

Abstract: In modern factory communication, the traditional field bus type technology has gradually given way to Ethernet-based technology (e.g., industrial Ethernet, traditional Ethernet). Therefore, the Ethernet-based Time Sensitive Network (TSN) specified by the IEEE 802.1 working group quickly became the first choice for industrial real-time networks. TSN makes it possible to achieve deterministic real-time communication over Ethernet. It requires that the transmission of time-triggered (TT) data flows in the network be transmitted according to a pre-planned schedule. However, if TT flows' routing paths are not carefully chosen (for example, adopting the shortest path algorithm) before their scheduling, the network capacity will be limited. This is because some links saturate faster than other links, preventing more TT flows from being added into the network. Such load imbalance also leaves less link capacity for the secondary rate constrained (RC) flows, resulting in higher latency. In this paper, we propose a two-stage load-balancing routing heuristic algorithm for TT flows to avoid congested links as much as possible, and also reap the benefit from the shortest path algorithm. It can achieve low end-to-end delay and also ensure a high degree of load balance.

3 Cloud-Native IP-Based Mobility Management: A MIPv6 Home Agent Standalone Microservice Design

Akos Leiter, Edina Lami, Daniel Huszti, Peter Kulics, Mohamad Saleh Salah, Nandor Galambosi, Laszlo Bokor

Abstract: The ever-increasing traffic and mobility events impose an unprecedented load on mobile networks. Meanwhile, the number of connected users and devices has been growing continuously; hence IPv6 is necessary to serve them. The mobility extension of IPv6 (Mobile IPv6) can also support and handle the rising demand for mobility management in the IP layer. At the same time, concepts like Network Function Virtualization, Software Defined Networks, and microservice architectures have changed the landscape of telecommunication services. In this paper, our prototype implementation is measured and evaluated: what containerization causes with different MIPv6-related traffic types on the top of Kubernetes. Additionally, Kubernetes Container Network Interface types are compared for a microservice and container-based standalone Home Agent of cloud-native Mobile IPv6 implementation.

4 Service-Based EMF Monitoring in the Environment with Mobile Phone Technologies

Nikola Djuric, Dragan Kljajic, Nikola Kavecan, Vidak Otasevic, Snezana Djuric

Abstract: A transformation to digital society resulted with an exponential increase in the use of wireless personal communication devices (mobile phones, WiFi/Bluetooth devices, etc.), which are based on electromagnetic field (EMF) radiation. The newest generation of mobile phone technology - 5G should bring higher data transfer rates, with increased capacity of network, comparing to 2G/3G/4G generations. However, its physical implementation will further raise artificial EMF radiation in human surroundings, inducing concerns on risks related to the human health. Thus, some innovative techniques of EMF monitoring should be employed, providing information and comparison of EMF radiation patterns among different generations of mobile phone technologies. This paper presents some technical details of modern, services-based EMF monitoring approach, employed in the Serbian EMF RATEL monitoring network. Also, the initial results of simultaneous EMF monitoring in 2G/3G/4G and 5G frequency bands will be given and discussed.

Session SS05 - Teletraffic Models, Traffic Engineering and Network Optimization

Start: 15:00 End: 16:00
Location: Room B
Session Chairs: *Michael D. Logothetis, University of Patras and Ioannis Moscholios, University of Peloponnese*

1 Call Admission Control Under a Probabilistic Bandwidth Reservation Policy and Handover Queueing in Mobile Hotspots

Marinos Vlasakis, Irene Lidia Keramidi, Ioannis Moscholios, Panagiotis Sarigiannidis, Michael D. Logothetis

Abstract: In this paper we study a mobility-aware call admission control algorithm in a mobile hotspot. More specifically, we consider a vehicle which has an access point of a fixed capacity and may alternate between stop and moving phases. In the stop phase, the vehicle services new and handover calls. To prioritize handover calls a probabilistic bandwidth reservation (BR) policy is considered where a fraction of the capacity is reserved for handover calls. Based on this policy, new calls may enter the reservation space with a predefined probability. In addition, handover calls have the option to wait in a queue of finite size if there are no available resources at the time of their arrival. In the moving phase, the vehicle services only new calls under the classical complete sharing policy. In both phases, calls arrive according to a Poisson process, require a single bandwidth unit for their acceptance in the system and have an exponentially distributed service time. To analytically determine the various performance measures such as call blocking probabilities an efficient iterative algorithm is proposed.

2 Machine Learning Aided Performance Estimation in Single Retry/Threshold Loss Models

Dimitrios Uzunidis, Irene Lidia Keramidi, Ioannis Moscholios, Michael D. Logothetis, Charalampos Z Patrikakis

Abstract: In this paper, we show that the exploitation of machine learning algorithms can significantly improve the accuracy of estimations in single retry/threshold multi-rate loss systems when it is combined with analytical expressions. In particular, we propose machine learning as a solution only in cases where the analytical solutions are erroneous due to their employed approximations. As a consequence, by using this methodology not only the modelling error can be significantly decreased when it is compared against simulation results but also the computational complexity of the combined solution remains very low. To validate our approach, we exploit seven machine learning algorithms and we examine their improvement for 3000 different operational cases. We show that the absolute relative error can be decreased to below 10% for all four examined metrics when a deep neural network is combined with closed-form expressions.

3 Accelerating Veins Simulations by Utilizing Task Parallelism on a HPC Cluster Without Introducing Major Inaccuracies

Markus Fritscher, Gabriel Dengler, Cord Bleibaum, Michael Niebisch, Reinhard German

Abstract: The evaluation of large-scale vehicular networks has proven difficult. The researcher has to either do a lot of experiments, reduce simulation accuracy or endure simulation runtimes prohibiting a reasonable investigation. We present a framework that allows preserving simulation accuracy while maintaining reasonable simulation times by cutting the to-be-investigated area into individual tiles. Instead of running on a single CPU core we are able to run the simulation on hundreds of HPC servers in parallel. This yields a speedup of several orders of magnitude, allowing the simulation of entire cities. We validate our approach by investigating different access-point distributions for the city of Ingolstadt.

4 Inequalities Between Time and Customer Averages for GI/G/c/K Queues

Shigeo Shioda

Abstract: The relationship between time and customer averages for GI/G/c/K queues is studied based on the convex-order inequality between the distribution of interarrival times of customers (packets) and the exponential distribution having the same mean with the interarrival time of customers. It is shown that the interarrival-time distribution being smaller (or larger) than an exponential distribution with respect to the convex order is a sufficient condition for the inequalities between time and customer averages. The result of this paper is an extension of the existing results on the inequalities between time and customer averages.

Session FIBER 02 - Colloquium on Optical Fiber Devices and Sensing Applications

Start: 15:00 End: 16:15
Location: Room C
Session Chair: *Qiang Wu, Northumbria University*

1 An Ultra-Short Polarization Beam Splitter Based on Dual-Core Photonic Crystal Fiber with a Nematic Liquid Crystal Filled Air Hole

Yanan Xu, Jinhui Yuan, Yuwei Qu, Binbin Yan, Kuiru Wang, Qiang Wu

Abstract: An ultra-short polarization beam splitter based on dual-core photonic crystal fiber with a nematic liquid crystal filled air hole is designed. The designed ultra-short PBS has a splitting length of 65 μm and the maximum extinction ratio of 101.72 dB. In addition, its bandwidth is about 364 nm, which covers the most O + E + S + C + L communication band.

2 D-Shaped Photonic Crystal Fiber Plasmonic Sensor Based on Hollowed-Out Smiley-Faced Hole

Hongxiang Zhao, Jinhui Yuan, Yuwei Qu, Binbin Yan, Kuiru Wang, Qiang Wu

Abstract: A D-shaped photonic crystal fiber surface plasmon resonance sensor with a hollowed-out smiley-faced hole for highly sensitive liquid RI sensing is proposed. The sensor has a maximum sensitivity of up to 17100 nm/RIU in the range of 1.3 to 1.41.

3 A Polarization Beam Splitter Based on Hollow-Core Photonic Band Gap Fiber

Haoran Liu

Abstract: A polarization beam splitter based on dual-core photonic band gap fiber structure is proposed. The optimum length of the beam splitter is 1195 um, the extinction ratio at 1.55 um is -94 dB, and the bandwidth is 51 nm (1.53-1.581 um). The beam splitter has a good beam splitting effect in the whole C-band.

4 Study on Fabrication and Sensing Characteristics of a D-Shaped Fiber Long-Period Fiber Grating

Houchang Li

Abstract: A long-period fiber grating (LPFG) structure based on D-shaped fiber is proposed, where a graphene oxide (GO) film layer is deposited on the fiber by the dipping method to jointly construct a new humidity sensor. The D-shaped fiber structure can provide a stronger evanescent field than conventional fibers, and therefore offer much higher sensitivity. The maximum average sensitivity achieved by the sensor in the range of ambient humidity of 40 - 80% RH (relative humidity) is -0.1949 nm/%RH, and the linearity is 0.997. The experimental results show that the humidity sensor has higher response sensitivity, and improved linear response characteristics. It provides a beneficial exploration for the development of low-cost, easy-to-manufacture, and highly sensitive fiber-optic humidity sensors.

5 An Improved Spectral Demodulation Algorithm Based on Cross Correlation for Chirped Fiber Bragg Gratings

Zhihao Wang, Yueming Zhang, Changyu Shen, Zhaokun Wang

Abstract: In this letter, we propose a simple and precise spectral demodulation algorithm for chirped fiber Bragg grating (CFBG). This algorithm relies on mutual correlation. It can be used to measure the nonuniform temperature field and reconstruct the temperature field. First, a linear CFBG is placed in an inhomogeneous temperature field, therefore the spectrum of CFBG is compressed. In order to calculate the spectral offset of CFBG at different positions, the spectrum of room temperature and the spectrum of the temperature field to be measured are segmented. Then, according to the different trend of the spectrum, the point at the rising edge of the spectrum is taken as positive, and the point at the falling edge of the spectrum is taken as negative. Finally, the piecewise spectra are selected from the two spectra and the mutual correlation coefficient is calculated. The group with the largest correlation coefficient has the strongest correlation, and the offset of this group is calculated. Compared with the traditional chirped grating spectral demodulation algorithm, this demodulation method improves the accuracy and resolution, and the nonuniform temperature field can be reconstructed.

Session SS1 - Joint Radar and Communications for 6G Networks

Start: 16:30 End: 17:30
Location: Auditorium II
Session Chair: *Daniel Castanheira, Instituto de Telecomunicações (IT)/University of Aveiro*

1 Quasi-Orthogonal SFBC for Monostatic MIMO ISAC Scenarios

Leonardo Leyva, Daniel Castanheira, Adão Silva, Atílio Gameiro

Abstract: This paper studies the performance of the quasi-orthogonal Tirkkonen spatial-frequency block code (SFBC) for integrated sensing and communication (ISAC) scenarios. The considered scenario is a MIMO monostatic ISAC base station (BS), where transmitter and radar antenna arrays are co-located enabling the virtual array concept. The quasi-orthogonal Tirkkonen SFBC is encapsulated in an OFDM waveform, the radar processing is performed over the resulting OFDM frame. The performance in terms of radar and communication metrics of Tirkkonen SFBC is presented and compared with orthogonal Alamouti SFBC and the spectrally interleaved waveform approach, widely used in radar-like scenarios. The resulting Mean Square Error (MSE) of the Angle of Arrival (AoA) is chosen as the radar metric while the bit-error-rate (BER) is used to present the communication performance. The results show that Tirkkonen is a good candidate for future ISAC scenarios.

2 Indoor near Field Impact in the RADAR Signals for 6G Mobile Networks Integration

Daniel Albuquerque, Beatriz Cruz, Carolina T. S. Gouveia, Vitor Coelho, Pedro Pinho, João Matos, Arnaldo Oliveira, Nuno Borges Carvalho

Abstract: The use of RADAR is an important part of 6G mobile networks. However, its usage in indoor environments is not as well studied as it is for outdoors. Despite the considerable amount of information found in the literature related to RADAR signals, most of this information is only valid for outdoor environments. Conversely, such information might not be always applied for the indoor context, since the RADAR operates most of the time in its near-field region. This paper presents a study of the indoor near-field impact in the RADAR signals for 6G mobile networks integration. A circular and a square plate is used to approximate the behavior of a possible target for that purpose. Moreover, a simulation with different plate sizes and wave frequencies will be presented. The simulation results demonstrate that in the near-field region, the received power decreases with frequency, does not increase with the target area, presents strong nulls, and has an upper and lower bound.

3 An Overview of Intelligent Reflecting Surfaces for Future Wireless Systems

Ali Gashtasbi, Mario Silva, Rui Dinis

Abstract: This paper reviews current publications as well as the concept of the intelligent reflecting surface (IRS) in future wireless networks. The unpredictable fading of wireless channels has become one of the most significant performance bottlenecks. The IRS consists of a large number of metasurface devices that may be individually adjudicated to add phase changes to signal reflections. It may actively alter the signal propagation parameters in favor of signal reception and so achieve the idea of a smart radio environment. In this survey, we first introduce essential concepts of the IRS and the realizations of its configurability. Then, we discuss the joint optimization of the IRS's phase control and the transceivers' transmission control in different network design problems, e.g., capacity maximization and energy minimization problems, beamforming discussion of IRS-assisted wireless networks, and using deep learning method for discussion in IRS. Finally, we highlight important practical challenges that will be of interest, such as security transmission, UAVs, and mm-Wave communication.

4 A Feasibility Study on Real-Time Concealed Object Detection in Foliage Using STDCC Radar

Luis Duarte, Mario Vala, Carlos M. Ribeiro, Luis Nero Alves, Carlos A. Fernandes, Rafael F. S. Caldeirinha

Abstract: This paper reports on the first results of a Swept Time-Delay Cross Correlator (STDCC) based radar performance for the detection of concealed objects in a foliage. The real-time STDCC radar operating at 25 GHz with 500 MHz bandwidth detection capabilities is benchmarked together with a VNA technique using a central frequency of 11 GHz with 18 GHz bandwidth. A set of measurements were performed to assess the attenuation caused by multiple trees and compare them with literature model estimations. Both radar techniques may accurately detect the position of a concealed corner reflector, showing their great stability over time. The object distance accuracy was confirmed to be related with the used bandwidth, having both technologies been compared with different and same bandwidths. Our analysis also confirmed the expected 20 dB of single tree attenuation, showing similar detections/attenuations with both radar systems.

Session SS2 - Advancements and Emerging Trends in Cybersecurity

Start: 16:30 End: 18:00
Location: Room A
Session Chair: *Vassilios G. Vassilakis, University of York*

1 iDAM: A Distributed MUD Framework for Mitigation of Volumetric Attacks in IoT Networks

Suvrima Datta, Aneesh Bhattacharya, Risav Rana, Venkanna U.

Abstract: The rapid popularity of IoT devices has led to an escalating number of sophisticated cybersecurity attacks. Prior security mechanisms such as IDS are inaccurate and incur high computational costs for resource-constrained IoT devices, hindering their scalability to large networks. MUD has been introduced to overcome IoT security challenges. However, it cannot mitigate volumetric attacks in IoT networks. This paper proposes iDAM: a distributed self-learning, autonomous system to detect and mitigate volumetric attacks in IoT networks. iDAM monitors and authenticates the behavioral profiles of MUD compliant IoT devices and builds specific-device-type OC-SVM models aggregated using federated learning. The solution can cope with the occurrence of volumetric attacks at several levels of the IoT infrastructure and the compromise of the internal components of the proposed solution. We have extensively evaluated our solution with the IoT network intrusion dataset, which shows that iDAM can efficiently mitigate several volumetric attacks by detecting anomalous packet flows in the network with an AUC of 0.9597. Testing iDAM against a real-time SYN flood attack in an experimental setup and its ability to quickly mitigate the attack solidifies the conclusion that it can be deployed in a real-time environment to detect and mitigate volumetric attacks effectively.

2 Simulating Malicious Attacks on VANETs for Connected and Autonomous Vehicle Cybersecurity: A Machine Learning Dataset

Safras Iqbal, Peter Ball, Muhammad H Kamarudin Kamarudin, Andrew Bradley

Abstract: Connected and Autonomous Vehicles (CAVs) rely on Vehicular Adhoc Networks with wireless communication between vehicles and roadside infrastructure to support safe operation. However, cybersecurity attacks pose a threat to VANETs and the safe operation of CAVs. This study proposes the use of simulation for modelling typical communication scenarios which may be subject to malicious attacks. The Eclipse MOSAIC simulation framework is used to model two typical road scenarios, including messaging between the vehicles and infrastructure - and both replay and bogus information cybersecurity attacks are introduced. The model demonstrates the impact of these attacks, and provides an open dataset to inform the development of machine learning algorithms to provide anomaly detection and mitigation solutions for enhancing secure

communications and safe deployment of CAVs on the road.

3 ML-Based Detection of Rank and Blackhole Attacks in RPL Networks

Philokypros P. Ioulianou, Vassilios G. Vassilakis, Siamak F. Shahandashti

Abstract: Although IoT security is a field studied extensively, recent attacks such as "BotenaGo" show that current security solutions cannot effectively stop the spread of IoT attacks. Machine Learning (ML) techniques are promising in improving protection against such attacks. In this work, two supervised ML algorithms are trained and evaluated for detecting blackhole and rank attacks in RPL networks. Extensive simulations of the attacks are implemented to create a dataset and appropriate fields are identified for training the ML model. We use Google AutoML and Microsoft Azure ML platforms to train our model. Our evaluation results show that ML techniques can be quite effective in detecting blackhole and rank attacks, achieving a precision of 93.3%.

4 Performance Analysis of the QKD Algorithm Using AES and RS

José Azócar, Ismael Soto, Sebatián Lara, Sebastian Gutierrez, Pablo Palacios Játiva, Cesar Azurdia

Abstract: The purpose of this paper is to present a multisensor system with quantum key exchange at the source level and non-binary data transmission at the channel level using the quantum AES algorithm. We differentiate between the classical paradigm based on numerical complexity and the quantum paradigm based on the uncertainty principle. Studies of Bit Error Rate (BER) curves compared a Reed Solomon code with compression and an unencrypted channel are carried out, obtaining a performance of 6 dB and 6.5 dB for a BER of 10{-3}, respectively. Detection studies are also carried out against the “man-in-the-middle" attack, reaching a probability of approximately 90%.

5 IoT Botnets: Characteristics, Exploits, Attack Capabilities, and Targets

Leona McNulty, Vassilios G. Vassilakis

Abstract: In recent years, the world has witnessed a significant increase in the number of used IoT devices, with a global and continuous rise in the demand for their multi-purpose applications. However, malicious use of IoT devices began to emerge among cyber-criminals. IoT-enabled cyberattacks and botnets, such as the Mirai botnet and its variants and imitators, demonstrate that the industry needs to better secure IoT devices and networks; otherwise, there will be

higher risks of exposing the Internet infrastructure and services to increasingly disruptive DDoS attacks. This paper presents the results of a study of IoT botnets. We focus on their distinctive characteristics, exploits used, and cyberattack capabilities. In total, we have reviewed and compared 41 recent IoT botnets. We also present details of the main CPU architectures targeted by these botnets. We illustrate that IoT botnets pose a significant threat to private individuals and enterprises by employing sophisticated evasion mechanisms, encrypted communication, and targeting a wide range of systems and networks.

6 Security-Focused Prototyping: A Natural Precursor to Secure Development

Sam J Attwood, Nana Onumah, Katie Paxton-fear, Rupak Kharel

Abstract: Secure development is often thought of as a proactive approach to cyber security. Rather than building a technological solution and then securing it in retrospect, secure development strives to embed good security practices throughout the development process and reduce risk. Unfortunately, evidence suggests secure development is complex, costly, and limited in practice. This article therefore introduces security-focused prototyping as a natural precursor to secure development. Security-focused prototyping embeds security at the beginning of the development process, can be used to discover domain specific security requirements through active learning, and can help communicate the complexity of secure development to organizations such that the resources and commitment it requires are better understood. A case study considering the application layer of an Internet of Things system is presented and shows that security-focused prototyping has the potential to facilitate further secure development through the achievement of well-established prototyping objectives, such as communication, active learning, and reduced time/costs. Future work could build on this work by conducting additional case studies to further explore the potential of security-focused prototyping and investigating the importance of fidelity with regards to security-focused prototypes.

Session SS3 - Emerging Topics in 6G Communications

Start: 16:30 End: 17:45
Location: Room B
Session Chair: *Sérgio Crisóstomo, Universidade do Porto*

1 Intelligent Reflecting Surface - Aided UAV Communications: A Survey and Research Opportunities

Anas Alkhatieb, Khaled M. Rabie, Xingwang Li, Galymzhan Nauryzbayev, Ramez Alkhatib

Abstract: The sixth-generation (6G) wireless communication network needs to achieve very high data rates, extremely low latency, high reliability, fully connected coverage, and energy efficiency. Unmanned aerial vehicles (UAVs) are considered as one of the promising technologies for the future of communications. However, limited battery capacity is a barrier to the effective spread of such solutions. Intelligent reflective surfaces (IRSs) that can reconfigure their reflection properties and electromagnetic absorption in real-time offer unparalleled opportunities to improve the wireless communication experience in difficult environments. In this respect, we highlight various use cases, research opportunities, and challenges for optimizing and designing wireless networks. Specifically, IRS carried by UAVs can meet important objectives in terms of future communications networks

2 Energy Optimization and Cost Reduction in Water Distribution Network

Dina Tarek, Haitham Hassan Mahmoud, Tawfik Ismail

Abstract: Since the majority of energy consumed by water supply systems is used in transporting and distributing water, in addition to the energy required to pump the water from its sources, energy consumption is significantly associated with the water demand. Several studies have been carried out to optimize pump operations to achieve appropriate pressure and reduce the energy associated with controlling water levels in storage facilities. In this paper, we develop an optimization and decision support technique for a Water Distribution Network (WDN) that considers energy efficiency by limiting the energy consumption of transport and distribution water operations. Therefore, three considerations are taken into account to reduce energy usage, which are: a) the tank demand pattern is redistributed using a genetic algorithm; b) the reservoir serving pattern is governed by game theory c) a decision-making algorithm is also proposed to select the best-suited controlling setting of the pump and valves based on the other two considerations.

3 Outage Performance of 6G NOMA Dual-Hop Hybrid RF-PLC System with Imperfect SIC

Ahmed Samir, Mohamed Elsayed Mohamed Elsayed, Ahmad El-Banna, Taissir Y. Elganimi, Khaled M. Rabie, Basem M. ElHalawany

Abstract: The combination of power line communications (PLC) and radio frequency (RF) is essential for implementing new applications in smart grid and vehicular communications. In this paper, we propose a non-orthogonal multiple access (NOMA) based dual-hop hybrid wireless-power line communication (PLC) system with a decode-and-forward relay. The wireless channel is characterized by Nakagami-{m} fading under an additive white Gaussian noise, while the PLC channel is characterized by a Log-normal distribution with Bernoulli Gaussian noise including both background and impulsive noise components. New closed-form expressions for the outage probability, and the asymptotic outage probability are derived under the practical assumption of imperfect successive interference cancellation (SIC) and verified via extensive representative simulations. For more insights on the outage performance, we also analyze the diversity order. Additionally, we proposed a power allocation optimization technique to achieve outage-optimal performance. The results show that the system outage probability improves as the arrival probability of the PLC impulsive component decreases. Finally, to highlight the achievable performance gain, the performance of the proposed system is compared against a benchmark OMA-based system.

4 Performance Enhancement via Partitioning Large Intelligent Surfaces in Downlink NOMA Networks

Madi Makin, Sultangali Arzykulov, Khaled M. Rabie, Galymzhan Nauryzbayev

Abstract: Low latency, high-data-rate, and massive connectivity are the requirements for the emerging wireless technologies that will give a chance to high-demanding and progressive innovations in many spheres. Reconfigurable intelligent surfaces (RISs) are considered to be a promising technology for the rising wireless communication standards. This paper studies the large intelligent surface (LIS) enabled wireless network deploying non-orthogonal multiple access (NOMA) over Nakagami-m channels with non-fixed LIS position. We propose the LIS partitioning method, where various LIS elements serve different NOMA users depending on their quality of service. Moreover, we also examine the effect of imperfect signal interference cancellation, the number of LIS elements, and their allocation amongst the users. The simulations and followed-up discussions are provided regarding the system's ergodic capacity measurements.

5 Outage Probability of ABCom NOMA Systems for 6G with IQI and RHIs

Dong kai Cui, Xingwang Li, Gaojian Huang, Khaled M. Rabie, Galymzhan Nauryzbayev, Basem M. ElHalawany

Abstract: This paper considers an ambient backscatter communication (AmBC)-Non-orthogonal multiple access (NOMA) system with both in-phase and quadrature phase imbalance (IQI) and residual hardware impairments (RHIs). In particular, derive the analytic expressions of outage probability (OP) of each node in the presence of ideal and non-ideal conditions. In order to get further insights, we analyze the asymptotic behavior of OPs at high signal-to-noise ratios (SNRs). Through the comparison of theoretical analysis and Monte Carlo simulation, the correctness of the conclusions are verified.

Session SS4 - Machine Learning for Biomedical Applications

Start: 16:30 End: 18:15
Location: Room C
Session Chair: *Monica Figueiredo, Polytechnic Institute of Leiria*

1 A Novel Artifact Removal Method for the SSVEP Signal Using Hybrid CCA-DWT and Comparative Analysis for Feature Selection and Classification in the P300 Signal

Seyedeh Nadia Aghili Kordmahale, Sepideh Kilani, Zabih Ghassemlooy, Qiang Wu, Afsane Maleki

Abstract: Electroencephalogram (EEG) based brain-computer interface speller is a communication rehabilitation tool to help patients suffering from motor disorders. A hybrid EEG signal based on steady-state visual evoke potential (SSVEP) and P300 signals is, although more efficient to have a robust speller application, however, there are some challenges including low signal-to-noise ratio, low information transfer rate, and classification accuracy in a smaller number of trials. To overcome these issues, this study proposes two approaches for both SSVEP and P300. For the former, a novel hybrid denoising approach based on canonical correlation analysis and discrete wavelet transform (DWT) was proposed, which offers a significant improvement in the single-flicker SSVEP signal. Furthermore, four feature selection techniques are applied to a combination of temporal features and DWT to remove irrelevant and redundant features in the P300 signal based on the rapid serial visual presentation paradigm. Then seven strong popular classification techniques are applied to P300 coefficient detection, where the proposed single-layer discriminative restricted Boltzmann machine has shown more robust results compared with other methods. The average character recognition accuracies among six subjects are 51±5% and 94±4% with the average data rates of 34±5 and 26±2 bit/min, for one and five repetitions, respectively.

2 Remote Detection of COVID-19 Using 5G and AI

Raul Zamorano-Illanes, Ismael Soto, Wilson Alavia, Veronica Garcia, Francisco Rau, Pablo Adasme

Abstract: This work presents a novel solution for the detection of COVID-19 cases from electrophoresis samples obtained from the sewerage system for pandemic control. This through the application of artificial intelligence and 5G cellular networks.

3 Reducing Calibration Time Using Novel Hybrid Transfer-Learning for P300-Based BCI Applications

Sepideh Kilani, Seyedeh Nadia Aghili Kordmahale, Zabih Ghassemlooy, Mircea Hulea, Qiang Wu

Abstract: P300 is an event-related potential determined by the changes in natural neurons activity, which occurs mainly as a response to the infrequent stimuli. Considering that the positive potential can be monitored by non-invasive methods such as electroencephalogram, and that the 'oddball' paradigm elicits deliberately this response, P300 can be used in brain-computer interfaces (BCI). P300-based BCI applications suffer from the subject dependency problem, which is one crucial issue in the real-time implementation, requiring time-consuming calibration and a large number of training samples for learning the model. In this paper, a new approach based on transfer learning to overcome these problems is proposed, where the fine-tuning ability of a deep neural network for high-level feature extraction is being used. Euclidean space data alignment approach is adopted to make feature extraction data give similar distributions. Finally, transferred features are applied to a single-layer discriminative restricted Boltzmann machine for P300 detection. We have used a state-of-the-art dataset (BCI Competition III dataset II) for evaluating the proposed method. The results show that the proposed technique offers robust performance using a small number of training samples compared to the previous studies.

4 Detection of Depression via Analyzing the Electroencephalograms Acquired Under Various Activities

Bingo Wing-Kuen Ling, Ruilin Li, Caijun Li

Abstract: This paper mainly studies whether the people are suffered from the depression or not via analyzing the electroencephalograms acquired under various daily activities. In particular, four patients are suffered from the depression and four people are healthy. They are asked to perform seven activities with the high concentration. Here, the conducted activities are the drawing activity, the eating activity, the doing computer exercises activity, the playing electronic games activity, the reading activity, the playing with the toys activity and the watching the television activity. The electroencephalograms are collected when these activities are conducted. Then, the electroencephalograms are filtered with the passbands of the filtered electroencephalograms being between 100Hz and 150Hz. Next, the empirical mode decomposition is performed. The first four intrinsic mode functions are used to extract the features. Finally, the back propagation neural network, the support vector machine and the random forest are used to classify between the depression patients and the healthy people. It is found that the highest classification accuracy is 89.27%. Therefore, it can be concluded that the electroencephalograms acquired under various activities can be used to detect whether a person has suffered from the depression or not.

5 Simple and Effective Signal Processing Pinpointing Subtle Premature Ventricular Contractions Inferred from Increasing Physical Effort

Aníbal J Ferreira

Abstract: Premature ventricular contractions (PVC), or extrasystoles, represent a type of cardiac arrhythmia that is common among the general population and, notably, among athletes or individuals who exercise frequently. PVC may be asymptomatic and not clinically relevant when their rate is low, up to around 0.5%, or may be symptomatic and clinically relevant when it is high, in the order of or above 10%. ECG analysis in association with a cardiac stress test is important to detect and characterize PVC and to diagnose the heart condition and operation. In this paper, we describe and test a simple signal processing approach that can be used to effectively pinpoint subtle PVC occurrences in various physical effort conditions. In this regard, we discuss i) three important conditions to be met such that PVC are categorized as benign, ii) the design and implementation of a cardiac stress test and ECG data collection, iii) the algorithm analyzing and extracting information from the detected PVC occurrences, and iv) we present and discuss the obtained results, and conclude on their significance.

6 Alzheimer's Detection with Speech Using Singular Spectrum Analysis Trend Extraction Method

Guozhao Liao, Bingo Wing-Kuen Ling, Charlotte Ho

Abstract: With the aging of the population in various countries, the impact of Alzheimer's disease on humans is becoming more and more obvious. It is very necessary to propose an Alzheimer's detection system. This paper attempts to use the singular spectrum analysis trend extraction method to complete the task of Alzheimer's detection with speech. First, the singular spectrum analysis is performed on the speech signal, and the components obtained by the singular spectrum analysis are divided into a trend part and a detrend part according to the energy ratio. Second, feature extraction is performed on the trend part and the detrend part of the speech signal respectively. These features include multi-dimensional voice program, the gammatone frequency cepstral coefficient and the Power-normalized cepstral coefficients. Then, use random forest to calculate the importance of feature vectors, and select the top 30 features that random forest considers the most important as the features used in this article. Finally, random forest is used for classification.

7 The Development of a Low-Cost Exoskeleton Arm for Rehabilitation Use

Ramon Sargeant, Adrian Als, Evrico P Inniss

Abstract: This research is based on development of a low-cost exoskeleton arm to assist in the rehabilitation of individuals who may have difficulty using their forearm or had a minor stroke.

Although there are existing exoskeleton arms, they tend to be very expensive ranging from 5000 - 20,000+ USD. These exorbitant costs are a major inhibitor for persons in the developing countries of the Eastern Caribbean. This research was focused on building a fully functioning exoskeleton hand to help with the rehabilitation process while keeping the expenses at a reasonable consumer price. The exoskeleton hand was controlled with a microcontroller which functioned as the brain of its operations, actuators as the muscles of the arm and sensors which relayed the information to the microcontroller. The exoskeleton was built using 3D technology to minimize the development cost and avoid metals given the corrosive damage that can be caused by the quantity of sea salt in the Eastern Caribbean (Barbados) atmosphere There were experiments conducted whereas the users were asked to perform a set of actions (e.g., lifting forearm, clenching) while wearing the exoskeleton arm. The exoskeleton arm supported their movements when doing said actions.

Day 2 - 21 July 2022

Plenary Talk 03

Start: 09:00 **End:** 10:00
Location: Auditorium II
Session Chairs: *Luis Nero Alves, DETI, Universidade of Aveiro, Instituto de Telecomunicações and Zabih Ghassemlooy, Northumbria University*

P Guessing Random Additive Noise Decoding (GRAND) or how to stop worrying about error-correcting code design

Muriel Médard
Massachusetts Institute of Technology

Abstract: To maintain data integrity in the face of network unreliability, systems rely on error-correcting codes. System standardization, such as has been occurring for 5G, is predicated on co-designing these error-correcting codes and, most importantly, their generally complex decoders, into efficient, dedicated and customized chips. In this talk, we show that this assumption is not necessary and is has been leading to significant performance loss. We describe "Guessing Random Additive Noise Decoding," or GRAND, by Duffy, Médard and their research groups, which renders universal, optimal, code-agnostic decoding possible for low to moderate redundancy settings. Moreover, recent work with Yazicigil and her group has demonstrated that such decoding can be implemented with extremely low latency in silicon. GRAND enables a new exploration of codes, in and of themselves, independently of tailored decoders, over a rich family of code designs, including random ones. Surprisingly, even the simplest code constructions, such as those used merely for error checking, match or markedly outperform state of the art codes when optimally decoded with GRAND. Without the need for highly tailored codes and bespoke decoders, we can envisage using GRAND to avoid the issue of limited and sub-optimal code choices that 5G encountered, and instead have an open platform for coding and decoding.

Session OWC 06 - Applications

Start: 10:00 End: 11:00
Location: Auditorium II
Session Chair: *Monica Figueiredo, Polytechnic Institute of Leiria*

1 A Novel Blur Reduction Technique for QR and ASCII Coding in Smartphone Visible Light Communications

Vaigai Yokar, Hoa Le Minh, Zabih Ghassemlooy, Wai Lok Woo

Abstract: In this paper we present a new scheme to enhance the quick response (QR) code and American Standard code for information interchange (ASCII) in Smartphone-to-Smartphone Visible Light Communications (S2SVLC). The key technique is to avoid the repeated scanning of the blurred QR/ASCII code at the receiver. The technique will help to increase the QR/ASCII detection efficiency and the system data rate. The proposed technique includes converting the RGB image into the grayscale, applying contrast enhancement, scaling and binarizing the image. The experiment includes practical data acquisition and further processing in MATLAB. The obtained result indicates that, in the proposed technique the recovery rate can reach to 96%. We have carried out an end-to-end transmission of the system.

2 Impact of Optical Wireless Transmission Reliability on ECG Signal Quality

Amel Chehbani, Stéphanie Sahuguède, Anne Julien-Vergonjanne, Olivier Bernard

Abstract: In this article, we study an optical wireless ECG monitoring system for an elderly person, using an infrared link between a transmitter placed on the wrist and receivers on the ceiling of a room. It is assumed that the person walks across the room so that the transmission channel varies, which impacts the quality of the transmission and the ECG signal. Signal quality indices (SQIs) are a common measure used to assess ECG signal quality, regardless of acquisition and transmission conditions. Our main contribution is to evaluate the evolution of the SQIs, focusing on the spectral characteristics of ECG, as a function of the reliability of the optical transmission channel evaluated using lower layer metrics such as the signal to noise ratio (SNR) and outage probability. For this purpose, we develop a transmission chain in simulation in order to evaluate the two metrics during the walking of the person using a channel model including mobility. The results show that it is possible to ensure satisfactory ECG quality even if the received optical signal is strongly affected by channel variation due to mobility.

3 Deep Learning for BER Prediction in Optical Connections Impaired by Inter-Core Crosstalk

Sofia Esteves, João Rebola, Pedro Santana

Abstract: Four-level pulse amplitude modulation (PAM4) signals transmission in short-haul intensity modulation-direct detection datacenters connections supported by homogeneous weakly-coupled multicore fibers is seen as a promising technology to meet the future challenge of providing enough bandwidth and achieve high data capacity in datacenter links. However, in multicore fibers, inter-core crosstalk (ICXT) limits significantly the performance of such short-reach connections by causing large bit error rate (BER) fluctuations. In this work, a convolutional neural network (CNN) is proposed for eye-pattern analysis and BER prediction in PAM4 inter-datacenter optical connections impaired by ICXT, with the aim of optical performance monitoring. The performance of the CNN is assessed by estimation of the root mean square error (RMSE) using a synthetic dataset created with Monte Carlo simulation. Considering PAM4 interdatacenter connections with one interfering core and for different skew-symbol rate products, extinction ratios and crosstalk levels, the obtained results show that the implemented CNN is able to predict the BER without surpassing a RMSE limit of 0.1.

4 Automatic Traffic Light Detection Using AI for VLC

Henry Marina, Ismael Soto, Javier Valerio, Raul Zamorano-Illanes, Esteban Toledo-Mercado, Rui Wang

Abstract: This paper presents a method for performing traffic light detection using computer vision. Reliable traffic light detection and classification is crucial for automated driving in urban environments. By using big data and artificial intelligence, a complex dataset belonging to an urban area in China is preprocessed to determine the level of vehicular congestion, and then different machine learning algorithms are applied to a dataset of traffic light images in order to validate them in the urban environment to be studied, this process is explained step by step. The models obtained in this work can be applied in optical camera communication (OCC) systems, and also in intelligent transportation systems (ITS), using tracking channels for visible light communication (VLC). The two optical channels, VLC and OCC, are simulated in terms of the quality of information received in order to apply the previously generated datasets. In this work, a traffic light feature dataset has been generated from images and two traffic light classification models present in images and video frames have been generated from their features, obtaining a maximum accuracy of 94.52 %.

Session OWC 07 - Modeling and Simulation

Start: 10:00 End: 11:00
Location: Room A
Session Chair: *Rafael Perez-Jimenez, IDeTIC, Las Palmas University of Technology*

1 Physical Layer Security Enhancement in VLC Using Zero-Forcing Beamforming and Optimized LED Placement

Mahmoud Mohammadi, Seyed Mohammad Sajad Sadough, Zabih Ghassemlooy

Abstract: In this paper, we address the secure data transmission through visible light communication (VLC) using physical layer security (PLS) techniques and particularly, optical beamforming with the zero-forcing algorithm. More precisely, we consider the secrecy capacity of classical multiple-input single-output VLC so that the system can deal with eavesdroppers by minimizing the secrecy outage probability (SOP). The considered wireless channel is modeled by the Gaussian distribution, which is subject to amplitude constraints. We quantify the achievable secrecy capacity and SOP for the conventional line-of-sight VLC link and show that how the beamforming can determine the optimal placement of the transmitters. We also show that for a given SOP, the proposed optimal placement offers a signal-to-noise ratio gain of up to 6 dB compared to classical methods such as uniform placement of the transmitters.

2 An Interference to Noise Ratio Handover Mechanism for Mobile Visible Light Communication Networks

Meysam Mayahi, Antonio Costanzo, Valeria Loscrí, Anna Maria Vegni

Abstract: Visible Light Communication (VLC) is recognized as a complement communication technology that meets many hurdles of Radio Frequency (RF) systems. For example, VLC overcomes the limited RF spectrum resources for mobile users, even though its application demands an effective mechanism to handover among the different devices, in order to keep the connectivity consistent. In this paper, we introduce a new handover mechanism for mobile VLC nodes, based on a real time evaluation of the Interference-to-Noise Ratio (INR). This mechanism is coupled with four adaptive modulation schemes to further enhance the data rate. The communication system has been evaluated in respect of different parameters i.e., handover rate, delivered data per handover and handover delay ratio, through an extensive simulated campaign. An experimental validation carried out through software-defined approach, considering a small-scale scenario and low power Light Emitting Diodes (LEDs). A perfect results alignment between simulation and measurement show how suggested INR-based mechanism overcomes classical SNR-based handover for all performance parameters evaluated in this study.

3 Performance Evaluation of OFDM-Based Vehicular VLC Using Adaptive Bit-Loading

Mahdi Nassiri, Hossein Goorani, Gholamreza Baghersalimi

Abstract: This paper demonstrates the superiority of direct current-biased optical orthogonal frequency division multiplexing (DCO-OFDM) with adaptive bit-loading (BL) over DCO-OFDM without BL for the M-ary quadrature amplitude modulation (M-QAM) scheme in the visible light communications (VLC) system. Specifically, we implement VLC link using vehicle headlights and rear lights, and we provide a characterization of transmission performances in a vehicular scenario for distance 150 m between two vehicles. we intend to maximize spectral efficiency (SE) through the proper selection of modulation order, M, while satisfying a targeted bit error rate (BER). For the light-emitting diode (LED) modulation bandwidth of 4.5 MHz and the signal bandwidth equal to the LED bandwidth, the study shows the BER of M-QAM for an M range of 4 - 128. Results show that, a target BER of 7% forward error correction (FEC) limit, i.e. 3.8×(10)(-3), can be achieved for the adaptive BL system while bitrate and SE are ~26.2 Mb/s and ~5.82 b/s/Hz, respectively.

4 Equivalent Circuit Model for Large-Area Photodiodes for VLC Systems

Amany Kassem, Izzat Darwazeh

Abstract: An equivalent circuit model for large-area PIN photodiodes used in visible light communication (VLC) applications is described. The modelling aims to understand the effect of the photodiode intrinsic elements on the bandwidth of VLC receivers. The model parameters are extracted using impedance measurements of two large-area photodiodes. The extracted parameters identify the photodiode series resistance as a major bandwidth-limiting factor for VLC receivers, especially when employing low input impedance TIAs. However, such resistance is commonly ignored by circuit designers, since it is assumed to have a negligible effect on the TIA performance. To demonstrate the accuracy of the photodiode equivalent model, a design example of a low input impedance regulated cascode (RGC) TIA is described. The TIA is constructed using discrete components on a PCB. The designed TIA is measured using the proposed photodiode equivalent model versus a simplified model. In addition, a VLC link is constructed to measure the optoelectrical response of the large-area photodiode with the TIA. The frequency response measurements obtained from the full and simplified photodiode equivalent models are contrasted to the optoelectrical response, which verified that, unlike the simplified photodiode model, the proposed photodiode equivalent model can accurately predict the bandwidth of the VLC receiver.

Session FRONT-EDGE 01 - New Edge Application Use Cases

Start: 10:00 End: 11:00
Location: Room B
Session Chair: *Josep Prat, UPC*

1 Introduction to the Front-Edge Colloquium

Josep Prat

Abstract: The Front-Edge Colloquium ranges 6 sessions devoted to New edge uses cases, DSP&Transmission, Enabling technologies and Networking architectures, of fixed networks towards massive Fiber-To-The-Everywhere/Everything (FTTE). The key advances will be highlighted.

2 Edge Cloud Based Visual Inspection for Automatic Quality Assurance in Production

Pooyan Safari, Behnam Shariati, David Przewozny, Paul Chojecki, Axel Vick, Moritz Chemnitz, Johannes K. Fischer, Ronald Freund

Abstract: In line with the current trend towards local, private 5G networks, private on-premise edge clouds are becoming increasingly important for real-time, secure, robust and low-latency communication in production plants. While this is a proven means for larger manufacturing companies to implement a private/proprietary, real-time capable communication and data processing infrastructure for their production facilities, small and medium-sized enterprises (SMEs) cannot afford such infrastructures due to the high acquisition costs. Therefore, an off-premise edge cloud connected via a real-time communication network offers new, economically highly attractive possibilities, especially for manufacturing SMEs. In this work, we discuss the importance of edge clouds together with real-time and Time Sensitive Networks (TSN) for the realization of brand-new use-cases in industrial ecosystems. As a promising use-case for such an infrastructure, we present a remote quality assurance use-case in distributed production sites that can be realized with the powerful capabilities of Artificial Intelligence (AI) combined with real-time video streaming systems and high-speed, low-latency communication networks. We present the requirements and describe the advantages brought about by edge clouds for such a use-case.

3 Use Cases and Drivers for Optical Grooming in 5G Transport Networks

Juan Pedro Fernández-Palacios, David Larrabeiti, Luis M. Contreras, Gabriel Otero Pérez, José Alberto Hernández

Abstract: The introduction of fine granularity flexible optical networking technology featuring SDN-based fast reconfigurability brings the possibility of using the optical layer as the multiplexing layer for highly variable traffic rather than the packet layer. This optical-by-passing approach brings relevant savings in packet switching and provides QoS guarantees hard to provide at the packet layer without over-provisioning. The paper discusses several use cases that illustrate the potential of Sliceable Bandwidth Variable Transponders (S-BVTs) as ultra-low latency optical grooming alternative, especially under the scope of 5G services.

4 A Vision Towards F5G Advanced and F6G

David Hillerkuss, Marcus Brunner, Zhou Jun, Zhicheng Ye

Abstract: F5G advanced and F6G optical networks require a change in thinking due to the growing integration of physical and digital worlds. With increasing digitalization of more and more aspects of our work, life, and society, new opportunities arise. Our future infrastructure needs to pave the way towards a digitized and intelligent society - with features towards a new way of perceiving the world and new communication paradigms between humans, machines, and the physical world. In this paper, we show the methodology of ETSI ISG F5G to advance technology in a use-case driven and roadmap-based approach. To illustrate this approach, we show a few example use cases that a future optical communication infrastructure needs to support. Such use cases will support the development of the roadmap for F5G Advanced and F6G, consolidating and coordinating the different technology trends to support our vision of bringing digital to every person, home, and organization for a fully connected, intelligent world.

Session CSNDSP 03 - Security and Privacy

Start: 10:00 End: 11:00
Location: Room C
Session Chair: *João Paulo Barraca, University of Aveiro*

1 MIMO System Based-Constrained Quantum Optimization Solution

Abdulbasit M. A. Sabaawi, Mohammed Almasaoodi, Sara El gaily, Sándor Imre

Abstract: The multiple-input multiple-output (MIMO) systems provide high data rates and spectral efficiency performance. However, the fundamental problems with these technologies are their rising computational complexity and power consumption. The optimization issue is defined as a total transmit power minimization problem subject to the user rate target. The procedure of assigning different transmit power values to transmit symbols, and selecting the best optimum total transmit power with respect to the user's bit rate constraint is computationally hard, especially when the size of the possible transmit power scenarios becomes exponentially larger. For this sake, we proposed an efficient quantum strategy called constrained quantum optimization algorithm (CQOA), which searches exponentially faster for the optimum result. The proposed quantum strategy is compared with the genetic algorithm (GA). Simulation results highlight that the CQOA outperforms the GA in terms of computational complexity.

2 Privacy Preservation in Temporary Use of IoT Environments

Catarina Silva, Vitor Jesus, João Paulo Barraca, Rui L Aguiar, Gilad Rosner

Abstract: The increasing use of smart devices for monitoring spaces has caused an increase in concerns about the privacy of users of these spaces. Given this problem, the legislation on the right to privacy has been worked to ensure that the existing laws on this subject are sufficiently comprehensive to preserve the privacy of users. In this way, research on this topic evolves in the sense of creating systems that ensure compliance with these laws, that is, increasing transparency in the treatment of user data. In this paper, we propose a demonstrator-based strategy to provide users control over their stored data during the temporary use of an intelligent environment. This strategy includes transparency guarantees, highlights the right to forgetting, provides the ability to consent and proof of that consent. The prototype was tested considering a smart home as the smart environment and the results show an increase in user privacy when they are using a smart environment for a limited time and only after the stay.

3 Minimax Filter-Based Phase Tracking for Continuous-Variable Quantum Key Distribution

Farah Mahdi Alsalami, Sujan Rajbhandari, Zahir Ahmad, David Grace

Abstract: In local local oscillator (LLO)-based continuous-variable quantum key distribution (CV-QKD), a difference between the linewidth values of two free-running lasers at Alice and Bob induces a phase drift noise. This work proposes a novel minimax filter-based phase tracking that aims to minimize the phase drift considering maximum residual phase error to achieve optimal phase estimation. Simulation results show that the minimax filter offers a lower phase estimation mean square error (MSE) value compared to the Kalman filter when worst-case phase drift error due to high linewidth difference or high measurement noise values are considered.

4 Waveform Defence Against Deep Learning Generative Adversarial Network Attacks

Tongyang Xu, Zhongxiang Wei

Abstract: Physical layer (PHY) in communications is open to public and therefore it is highly vulnerable to over-the-air attacks such as spoofing, which will cause malicious communication resource occupation and result in reduced spectral efficiency. Traditional countermeasures rely on physical layer authentication (PLA) where unique hardware features and propagation channel features from legitimate users are difficult for an attacker to replicate. However, due to the advancement of artificial intelligence (AI), an intelligent attack method, based on generative adversarial network (GAN), is becoming more challenging. The GAN framework can use deep learning to impersonate a legitimate user including its signal pattern, hardware impairments and wireless channel characteristics. Therefore, traditional PLA methods will not work well in such GAN attack scenarios. This work will deal with the GAN attack challenge from a waveform design perspective. We investigate three waveform candidates with unique signal features such as orthogonality, non-orthogonality and windowing. Simulation results reveal that GAN attackers can successfully learn waveforms with either orthogonal or non-orthogonal features while it is difficult to learn the windowing characteristic. Therefore, this work reveals a robust waveform defence solution to combat with intelligent GAN attacks.

Session OWC 08 - Optical Camera Communications

Start: 11:30 End: 12:30
Location: Auditorium II
Session Chair: *Ismael Soto, University of Santiago*

1 Transmitter Identification Using Frame Reconstruction in Rolling Shutter Based Systems

Miguel Rêgo, Pedro Fonseca, Luis Nero Alves

Abstract: This paper proposes a reconstruction algorithm for rolling shutter based Optical Camera Communication (OCC) systems transmitting static identifiers (IDs), considering a system comprised of a camera and a circular light source, in the conditions when the ID frame is only partially detected in the image. We present a baseline algorithm as reference for the frame recovery success rate (FRSR) and propose a reconstruction algorithm to improve this metric. Our proposal is based on the idea of capturing multiple small frame fragments and reassembling them, in order to successfully recover the transmitted ID. We prove that, for 6-bit words, we can recover the original word with 100% certainty with four fragments of five bits each. Furthermore, our algorithm increases the maximum transmission distance from 5 m to around 12.5 m, using a light source with 15 cm diameter.

2 Spectral Signature Multiplexing in Multispectral Camera Communication

Daniel Moreno, Victor Guerra, Julio Rufo, Jose Rabadan, Rafael Perez-Jimenez

Abstract: Optical camera communication (OCC) is a technology foreseen to have a fundamental role in future communication applications due to the ubiquity of the cameras embedded in most consumer electronic devices and their increasing capabilities (high resolution, scanning frequency, etcetera). However, high-spectral-resolution cameras, such as multispectral cameras, present particular characteristics that can be exploited to provide new features to OCC links. Furthermore, as LED spectral responses are different when their temperature changes, more than one communication channel can be achieved using the same LED device if the camera can capture those modifications and distinguish the different LED spectral signatures due to the temperature variation. This novel approach is followed in this research, including some equalization techniques applied to the channel matrix to improve the extraction of the transmitted signal in the receiver reducing the inter-channel interference (ICI). This work shows that up to two distinct channels can be obtained with the same LED at different temperatures, getting a bit error rate (BER) below the forward error correction (FEC) limit.

3 Optical Wireless Hybrid VLC/OCC System Based on a Single Centralized LED

Juan A Apolo, Shivani Rajendra Teli, Vicenc Almenar, Beatriz Ortega, Stanislav Zvanovec

Abstract: In this paper, we present the experimental demonstration of a hybrid visible light communications (VLC) and optical camera communications (OCC) system based on a single centralized light emitting diode (LED) coupled with a plastic optical fiber (POF). Two data streams of 88 Mb/s and 4 kb/s are point-to-point transmitted simultaneously and passively distributed over a 20 m POF and 3 m free space optics links (FSO), where high- and low-speed signals detection is provided by a photodiode (PD) and an optical camera-based receivers, respectively. The system aims to provide different services and/or applications to the end-user regardless of the employed devices with the lack of intermediate electro-optic conversions, network simplicity and low cost, as major advantages.

4 A Novel Unilateral Optical Camera Communication-Based Positioning System

Navid Bani Hassan, Martin Harris, Geoffrey Archenhold

Abstract: In this paper, a novel optical camera communication visible light positioning system is demonstrated. We show that our system can achieve an accuracy of up to 1 cm with a root mean square error of 2.6 cm and frame processing time of <30 ms.

Session OWC 09 - System Design

Start: 11:30 End: 12:45
Location: Room A
Session Chair: *Mircea Hulea, Technical University Gheorghe Asachi of Iasi*

1 Demonstration of an Adaptive Fractionally-Spaced Pre-Equaliser to Increase VLC System Data Rates

Xicong Li, Zabih Ghassemlooy, Stanislav Zvanovec, Hoa Le Minh, Richard Binns, Ambrose Eromosele, Geoffrey Archenhold

Abstract: This paper demonstrates a VLC system using an adaptive fractionally-spaced pre-equaliser to extend the modulation bandwidth of the light-emitting diodes (LEDs). The proposed system has the flexibility of compensating for different LEDs by reloading the digital adaptive equaliser's coefficients without introducing any modification to the hardware. The key enabling power to obtain the optimal equaliser coefficients is from the well-known least mean square (LMS) algorithm. As a by-product, the proposed method offers a novel angle and a method to determine the pre-equaliser coefficients for those systems which do not have the updating algorithm implemented in a real-time manner but have to rely on a stored pre-set coefficient list. Finally, the experiment clearly shows the effectiveness of the proposed scheme by means of the improvement in the received eye diagrams.

2 Performance Analysis of a Graph Coloring Algorithm for Wavelength Assignment in Dynamic Optical Networks

Pedro Fonseca, João Rebola, Luís Gonçalo Cancela

Abstract: Dynamic optical networks will be crucial in global optical communications in the next 5-10 years in order to respond to the fast growing of on-demand services. Efficient network planning tools that deal with routing and wavelength assignment (RWA) problems are of paramount relevance in this dynamic scenario. In this work, a simulator for planning dynamic optical networks was developed, and several real networks were tested. In the simulator, we have implemented a graph coloring wavelength assignment (WA) algorithm named Small-Buckets algorithm that allows recoloring to occur. A comparison performance with the First-fit algorithm is performed in terms of the blocking probability, number of recolorings, number of colors used and simulation time. It is concluded that the Small-Buckets algorithm originates lower blocking probabilities than the ones obtained with the First-fit algorithm despite requiring a larger number of wavelengths and recolorings.

3 Demonstration of 20 Mbps LED Ultraviolet-C Communication over Medium Distance with Photon Receiver

Yifan Ding, Huabin Yu, Muhammad Hunain Memon, Chen Gong, Haiding Sun, Zhengyuan Xu

Abstract: Motivated by optical covert communication that can support both line-of-sight (LOS) and non-line of sight (NLOS) scenario, we demonstrate the possiblilty of the high data rate communication using self-fabricated deep ultraviolet (UV) light emitting-diode (LED). Both the LOS and NLOS UV communication links over realistic distances have been built. In LOS communication, we transmit data at rate from 2.5 Mbps to 20 Mbps in distances of 10 meters, 20 meters, and 30 meters. While in NLOS communication experiment, we test the channel over 6 meters at the reflection angle of 90 degrees, which is reflected by different solid materials. The transmitter adopts On-Off Keying (OOK) modulation, and the receiver part consists of a photomultiplier tube (PMT) and an oscilloscope. We process data on a computer in an offline manner, where supporting vector machine-based approach for signal detection is adopted. The experimental results show that in the LOS condition, the UV LED can provide stable communication at symbol rate 20 Mbps with bit-error rate (BER) below 2% in distance of 20 meters. Furthermore, we demonstrate that the UV photons can be reflected by smooth solid material at 90 degrees where symbol rate 10 Mbps with BER below 2% can be achieved.

4 Experimental Evaluation of a Hierarchical QAM VLC System

Carlos Guerra-Yánez, Antonio Mederos-Barrera, Stanislav Zvanovec, Zabih Ghassemlooy

Abstract: Hierarchical modulations have been used for the transmission of digital video broadcasting streams. The main objective is to mitigate the effects of noise on the perceived video quality. It is predicted that by the end of 2022 video streams will constitute 82% of the total Internet traffic. Therefore, the need for new wireless technology of visible light communication (VLC) to support the Internet of things (IoT) as part of the fifth generation (5G) mobile networks, particularly in radio frequency restricted environments. In a VLC system, hierarchical modulations can enhance the perceived quality of video streaming. In this work, for the first time, a hierarchical quadrature amplitude modulation (HQAM) is proposed and experimentally investigated for transmission of an image at the data rate of 8 Mbps. The results show the potential of VLC as an enabling technology for video streaming applications in IoT and 5G networks.

5 Towards Illuminating Optical Fiber Based Visible Light Communication Uplink

Matej Komanec, Carlos Guerra-Yánez, Klara Eollosova, Shivani Rajendra Teli, Stanislav Zvanovec

Abstract: We present a novel concept of visible light communication (VLC) uplink by introducing a distributed receiver (Rx) formed by an illuminating optical fiber (IOF) connected to the photodetector. The major functionality of IOF-distributed Rx is to sense/detect the light signal along the fiber span at a range of modulation frequencies coming from an on-off keying modulated light-emitting diode (LED) transmitter. We show that our proposed proof-of-concept of distributed Rx performs below the forward error correction limit of 3.8x10-3 at frequencies up to 400 kHz. We unveil the signal-to-noise ratio (SNR) limit of 19 dB must be maintained for successful data reception. Higher data rates are predicted once the concept is optimized, especially in terms of SNR. The proposed IOF-based scheme can be considered as a solution to the current challenges of VLC uplink.

Session FRONT-EDGE 02 - DSP & Transmission in Edge/Access

Start: 11:30 End: 12:30
Location: Room B
Session Chair: *Ioannis Tomkos, University of Patras*

1 Relation Between TDEC, Extinction Ratio and Chromatic Dispersion in 50G PON

Ivan Cano, Giuseppe Caruso, Derek Nesset, Giuseppe Talli

Abstract: We evaluate TDEC in a 50G-PON downstream through experiments and show the relation with receiver sensitivity at different fiber lengths and ER. The results show that TDEC effectively follows the penalty induced by transmission impairments.

2 Single Sideband Techniques for Next Generation Low-Cost UD-WDM Coherent PONs

Miquel Masanas, Victor Polo, Josep Prat

Abstract: Two applications for splitter-based, coherent passive optical networks are investigated. Coherent technologies enable ultra-dense lambda division multiplexing, increasing the dedicated data rates per application, the power budget and the spectral efficiency of the network, all within a single fibre for bidirectional transmission. In these works, optical single sideband (OSSB) technologies, along with RF modulations, are used to decrease complexity in the proposed networks.

3 Going Coherent to Upgrade Data Centers MMF Links Above 100G?

Roberto Gaudino, Giuseppe Rizzelli, Pablo Torres Ferrera, Fabrizio Forghieri, Andrea Carena, Antonino Nespola

Abstract: Large Scale Data Centers are still using Multi-Mode Fibers (MMF) for short distance links up to 300 meters, and IEEE is currently working on standardizing a new generation of systems for 100Gbit/s/lambda transmission using VCSEL+MMF transceivers on OM3 and OM4 fibers. These systems will still be based on IM-DD. In this paper, we experimentally and theoretically investigate on re-using already deployed OM3 and OM4 fibers using commercial coherent transceivers for bit rates up to 400G, showing that the the only practical limitation of this solution is connector offsets. We experimentally show a 200G transmission tolerating offsets above to 6 microns, and 400G up to 3 microns offset.

4 Controller for All-Optical Low Power/Cost Coherent Receiver Used in Short-Reach Systems

Konstantinos Moschopoulos, Ioannis Tomkos, Moshe Nazarathy

Abstract: The ICT industry faces huge challenges in the following years in terms of the bit-rate scalability and energy-efficiency of current transceiver solutions for the next-gen intra-datacenter, 5G fronthaul and access networks, rapidly extending their deployment. A key bottleneck is the cost and power consumption of available optical interconnects. To tackle these issues, we investigate the advancement of previously proposed all-optical solutions to be implemented in all-optical transceivers, discarding most of the power-hungry and costly DSP currently utilized in coherent receivers. Examining the optical link requirements for the targeted access/DCI networks, we present the design steps for a novel controller for all-optical polarization demultiplexing with a low-power footprint. We develop algorithms for polarization tracking in optical signal transmission through the fiber-optic link. In addition, we also present alternative solutions for the crucial function of carrier recovery in coherent receivers based on optical phase-locked loops.

Session CSNDSP 04 - Image Processing

Start: 11:30 End: 12:00
Location: Room C
Session Chair: *Rui Prior, Instituto de Telecomunicações, Universidade do Porto*

1 Contrast Enhancement Technique for Efficient Detection of Cloud from Remote Sensing Images

D Vijayalakshmi, Malaya Kumar Nath

Abstract: Satellite imaging is essential for a wide range of applications, including disaster management and recovery, agriculture, and military intelligence. Clouds are a severe impediment to all of these applications, and they must be normally identified and removed from a dataset before satellite images can be used. The quality of the satellite images affected by various factors during the acquisition process. In this paper, an enhancement approach is proposed to improve the quality of the satellite images for the purpose of improving the accuracy of the cloud detection process. The enhancement process utilizes the edge information extracted from the input image. The extracted edge information is used to create a variational map to equalize the intensities for the purpose of distributing the intensities to occupy the whole dynamic gray scale. Experiments have been performed to validate the efficiency of the enhancement process on the segmented results. From the analysis, it is observed that the enhancement process aids in improving the cloud detection which is indicated by the high values of the performance measures such as accuracy, F1-score, Dice and Jaccard co-efficient in comparison with the un-processed images from the sentinel-2 remote sensing dataset.

2 Evaluation of Offloading Points in the Device-Edge Environment

Chandra Shekar, Neena Goveas, Lucy Gudino

Abstract: Edge Computing is evolving as an enabler for providing critical requirements such as low latency, faster response time for applications like AR/VR, autonomous vehicles, patient monitoring, gaming, etc. In the IoT domain, these critical requirements are fulfilled by integrating edge computing with the host network to provide computation at the edge of the network. Researchers are now focusing on optimizing task offloading in terms of cost and the speed of task completion. There have been mathematical models proposed in the literature to estimate the optimal offloading points based on the parameters such as data size, link bandwidth, the processing speed of the end device and edge server, and network delay. In this paper, we propose a simulation-based mechanism to obtain optimal values for the offloading points. We use parametric analysis and show that the offloading points calculated using the mathematical models proposed deviate considerably from the actual values.

Plenary Talk 04

Start: 14:00 End: 15:00
Location: Auditorium II
Session Chairs: *João Paulo Barraca, University of Aveiro and Michael D. Logothetis, University of Patras*

P Multi-Mode MIMO Communications Beyond Beamforming

Emil Björnson
KTH Royal Institute of Technology

Abstract: Traditional wireless receivers operate in the far-field of the transmitter and the channels only involve a few angular directions. Under these conditions, the main role of antenna arrays is beamforming: to focus the transmitted signals in the strong angular directions and focus the reception correspondingly. This feature can be realized using classical phased-array technology. Several research developments towards 6G will change the status quo. Firstly, the carrier frequency is increasing towards the THz range, which proportionally increases the far-field limit. Secondly, the antenna array dimensionalities are increasing, particularly at the base stations, which further extends the far-field limit. Thirdly, the network densification shortens the propagation distances and increases the number of impactful propagation paths. These three factors will fundamentally change how point-to-point MIMO (multiple-input multiple-output) links must be designed in the future. We need to go beyond traditional phased-array-inspired far-field beamforming and consider the near-field focusing regime, where multiple parallel spatial layers can be transmitted using different spatial modes, even in line-of-sight scenarios with only a single angular path. In this keynote, we will revisit the fundamentals of point-to-point MIMO communications and explore the new features that arise when operating in the radiative near-field. The relation between spatial modes, spherical wavefronts, and array geometries will be described and illustrated. The hardware requirements for exploiting spatial modes will be analyzed. Are the spatial modes the next untapped signal dimensions that can sustain the capacity growth in future networks?

Session OWC 10 - Applications

Start: 15:00 End: 16:15
Location: Auditorium II
Session Chair: *Mohammad-Ali Khalighi, Ecole Centrale Marseille*

1 Pulse Amplitude Modulation for Electro-Optical Spiking Neural Networks

George-Iulian Uleru, Mircea Hulea, Othman Isam Younus, Zabih Ghassemlooy, Sujan Rajbhandari

Abstract: Spiking neurons represent the most accurate model of the neural cells by using pulses and timing for information processing and adaptation. Visible light communication can be leveraged to establish a wireless link between neurons in spiking networks even when neural areas are in relative motions. Typically, parallel transmission in electro-optical spiking neural networks is performed using wavelength division multiplexing, which is limited by the number of wavelengths used and multiple bandpass optical filters. This paper explores the possibility of using multi-level pulse amplitude modulation (PAM) in multi-input-optical-axons (MIOA) integrated by the parallel neural paths in a spiking neuron network (SNN). To evaluate PAM-MIOA, we implement an electro-optical SNN that controls the force of two anthropomorphic fingers actuated by the shape memory alloy (SMA)-based actuators. The voltage threshold level in PAM is automatically adjusted based on the reference optical power. Results show that the electro-optical SNN is able to hold an object when using PAM-MIOA even with the link misalignment.

2 Quantum Key Distribution for Visible Light Communications: A Review

Rida Zia-ul-Mustafa, Shadi Salehiboroujeni, Carlos Guerra-Yánez, Zabih Ghassemlooy, Hoa Le Minh, Stanislav Zvanovec

Abstract: Visible light communication (VLC) is a promising technology to improve the capacity of the existing indoor wireless communication systems. However, VLC also comes with security concerns as in line with other wireless and wired transmission systems. In this regard, quantum key distribution (QKD) has been proposed as an optimal solution to enhance the security of VLC networks at the physical layer. This paper serves as a review study of the QKD and highlights its state-of-the-art, applications and challenges in the prospect of securing the VLC systems.

3 Performance Analysis of Multiple Access m-CAP for Optical-Based Intra-WBAN Links

Oussama Haddad, Mohammad-Ali Khalighi, Zabih Ghassemlooy, Alexis Alfredo Dowhuszko, Stanislav Zvanovec

Abstract: Optical-based wireless body area networks (WBANs) are a promising solution for remote monitoring of vital signs in radio-sensitive environments such as healthcare facilities. When dealing with a large number of sensors coexisting within the same vicinity, multiple access (MA) solutions are necessary to manage the simultaneous access to the medium. In this paper, we investigate the use of MA multi-band carrier-less amplitude and phase (m-CAP) for intra-WBAN links. Using the outage probability criterion, we evaluate the performance of such a solution while accounting for realistic statistical channel models. Furthermore, we study the impact of system parameters such as system bandwidth, number of sub-bands, and roll-off factor on the link performance.

4 Adaptive Visible Light Positioning with MSE Inner Loop for Underwater Environment

Anna Maria Vegni, Valeria Loscrí

Abstract: The Internet of Underwater Things is a paradigm coming up beside well-known Internet of Things, but focusing on a specific environment that is the underwater scenario. Due to high attenuation and then limited performance, communication links in this harsh scenario are provided by dedicated wireless technologies. Underwater optical wireless communications allow to achieve high data rates and medium distances, thus resulting in an enabling candidate technology. Localisation in underwater environment is also a hot topic for all those underwater applications requiring high accuracy, such as marine ecology, seabed monitoring, etc. However, the dynamic changes that can suffer the underwater environment can limit the localisation accuracy, thus resulting in high estimation errors. In this paper, we present an adaptive localisation algorithm that exploit optical wireless connectivity, in the visible range. It takes into account information about water turbidity and is able to correct the estimation error in case of variable water conditions. The effectiveness of the proposed approach has been compared to a previous technique, which does not exploit information about the environment and then results to be effective only if exists an a-priori knowledge of the real water conditions.

5 Optimal Localization Design for Indoor Non-Interfering LED-Based System

Marwan Hammouda, Anna Maria Vegni, Valeria Loscrí

Abstract: Visible Light Communications (VLC) systems are designed to guarantee the twofold paradigm of both illumination and communications, thus resulting as a green technology. Indeed, it is possible to reduce cost and energy consumption by minimizing the number of Light Emitting

Diodes (LEDs), while still guaranteeing network performance. However, adapting existing VLC systems to offer localization services needs a few considerations, as localization requirements do not overlap with the communication ones. In order to guarantee localization services, Visible Light Positioning (VLP) systems should be designed accordingly in order to provide at least three optical signals per unknown location. In this paper, we design an indoor VLP network able to guarantee accurate localization estimate with a minimum number of LED devices. The proposed optimal LED deployment technique is designed for VLP network. Numerical results achieving a 20 cm localization accuracy are obtained for different geometrical settings.

Session CSNDSP 05 - Signal Processing

Start: 15:00 End: 16:00
Location: Room A
Session Chair: *Adão Silva, Instituto de Telelcomunicações*

1 Guidelines for Digital Twins in 5G Agriculture

Diego Fuentealba, Cristian Flores, Ismael Soto, Raul Zamorano-Illanes, Samantha Reid

Abstract: New devices for the Internet of Things (IoT) and 5G enable monitoring and controlling environments and objects in agriculture and other areas. Digital Twins is a growing concept that can connect IoT with applications to automate agriculture, predicting crops behavior through data analysis. However, there is a conceptual gap between the digital twin concept and its application to real development. This work performs a bibliometric analysis to identify the current works in the area. These works are analyzed to propose a meta-model that guides designs on digital twins in agriculture. The proposed design considers several meta classes such as communication devices, sensors, actuators, historical sensing, visualization, Human-Machine Interfaces, decisions, physical objects, and physical sectors. These metaclasses can work on Raspberry Pi with Jetson nano processors because they can be implemented in several languages and frameworks.

2 An Autonomous, Scalable and Low-Cost IoT Based Framework for Disaster Management System

Krishna Yadavalli, Lucy Gudino

Abstract: The Internet of Things (IoT) is playing a crucial role in Disaster Management. The amount of research produced, and the available commercial solutions are an indication of this fact. These solutions come in various forms and shapes in terms of complexity, features, and functionality. For a Disaster Management System, visibility and rapid-dynamic response are the keystones. Several proposals attempted to address this requirement with dashboards, node clusters, technology convergence, and event localization. These models employ various tools and platforms for data collection, visualization, analysis, alert management, and integration. However, they fall short of making the system simple and autonomous. This paper proposes a framework to bridge this gap by using low-cost off-the-shelf modules, an Observer node, hybrid connectivity and a message forwarding mechanism between the nodes. Despite being simple at its core, the framework is modular and hence can be extended to support a Disaster Management System of any size. Being open-ended leaves a lot of scope for future integration and scale-out.

3 Design and Experimental Evaluation of a Bluetooth 5.1 Antenna Array for Angle-Of-Arrival Estimation

Nuno M. Paulino, Luis M. Pessoa, André Branquinho, Edgar Gonçalves

Abstract: One the of the applications in the realm of the Internet-of-Things is real-time localization of assets in specific application environments where satellite based global positioning is unviable. Numerous approaches for localization relying on wireless sensor mesh systems have been evaluated, but the recent Bluetooth Low Energy (BLE) 5.1 direction finding features based on Angle-of-Arrival promise a low-cost solution for this application. In this paper, we present an implementation of a BLE 5.1 based circular antenna array, and perform two experimental evaluations over the quality of the retrieved data sampled from the array. Specifically, we retrieve samples of the phase value of the Constant Tone Extension which enables the direction finding functionalities through calculation of phase differences between antenna pairs. We evaluate the quality of the sampled phase data in an anechoic chamber, and in a real-world environment using a setup composed of four BLE beacons.

4 Experimental Validation of Zero Padding in SEFDM Systems Using Over-The-Air Transmission

Waseem Hazim Ozan Ozan, Ryan C Grammenos, Izzat Darwazeh

Abstract: Non-orthogonal spectrally efficient frequency division multiplexing (SEFDM) saves bandwidth by compressing the frequency spacing between the subcarriers. This is at the cost of introducing inter-carrier interference (ICI) between the subcarriers. This self-created ICI compounded by the signal degradation caused during wireless propagation in multipath environments, complicates the task of channel estimation and equalisation. Recent studies suggest that combining zero padding (ZP) with SEFDM signals can simplify the challenge of channel estimation and equalisation in the frequency-domain. In this work, we validate experimentally the new ZP scheme through over-the-air transmission of radio frequency (RF) signals. Experimental results prove that using ZP in SEFDM enhances the channel estimation and equalisation accuracy, in comparison to conventional cyclic prefix (CP)-SEFDM. In addition, it is shown that ZP-SEFDM offers robustness against timing offsets.

Session FRONT-EDGE 03 - Enabling Technologies

Start: 15:00 End: 16:15
Location: Room B
Session Chair: *Roberto Gaudino, Politecnico di Torino*

1 6G, Next G, and the Metaverse: Toward the Peak-Experience Machine

Martin Maier

Abstract: Johannes Gutenberg's invention of the printing press in 1450 revolutionized society and heralded 300 years of renaissance. While Gutenberg's invention gave birth to printing, the Internet's full potential still remains to be unleashed in the years to come. We do not yet know what the Internet truly is, though its impact is anticipated to be eventually similar or even superior to that of the printing press. Measured in Gutenberg time, we stand today at about the year 1481 with the progression of disruption in society. Note that Luther was born in the year 1483. Hence, the Internet's Martin Luther is yet to come. This paper aims at developing an overarching narrative for future 6G and Next G networks, which go beyond the incremental 6G=5G+1G mindset of past generations of mobile networks and also involve major over-the-top Internet players, including Apple, Google, Microsoft, as well as Facebook. We focus particularly on the emerging Metaverse, the anticipated successor to today's mobile Internet, which will be about being inside the Internet (rather than simply looking at it from a phone screen) and producing peak-experiences. This is in contrast to only printing pamphlets about them, as Luther had to do in a pre-Internet era.

2 From prototyping to volume production of integrated photonics in the JePPIX ecosystem

Sylwester Latkowski

Abstract: Integrated photonics enables a wide range of applications, including front-edge, next-generation solutions for communication networks. The final products using photonic integrated circuits require short design-in windows, efficient prototyping, and scale-up to production. The JePPIX ecosystem offers such services and a seamless transition from an idea to a product.

3 On the Enhancement of Unamplified Optical Coherent Systems

Beatriz Oliveira, Fernando Guiomar, Carmo Medeiros, Paulo P Monteiro

Abstract: With coherent optical systems expanding their use to short-reach applications, it is

imperative to achieve a cost and power-efficient solution that allows massive deployment. As increasingly higher data rates are required for shorter distances, the standardization of 400ZR and 800G for coherent transceivers is motivating the pursuit of unamplified systems, giving rise to new challenges, particularly due to the inherent peak-power constraint. In this paper, we discuss methods to improve the performance of unamplified coherent systems; particularly, we show the impact of pulse shaping and how it might undermine the system performance, and show how new advanced methods such as probabilistic constellation shaping can be used within these systems.

4 Hybrid PIC+ASIC Quasi-Coherent Receiver for TWDM-PON

Francisco Manuel Rodrigues, João Santos, Carla Rodrigues, Antonio Teixeira

Abstract: An hybrid integration of a PIC and an ASIC for achieving quasi-coherent receiver designed for tunable 10 Gbit/s applications is presented. This assembly holds the key functionalities for enabling integrated, highly efficient, tunable transceivers which can also enable TWDM-PON.

5 Symmetric 50G-PON: enabling photonic components and technologies

Ricardo Rosales

Abstract: 50G-PON is expected to be the technological solution for supporting high bandwidth services for residential optical access and for providing optical transport for wireless communications towards smart cities and smart factories. We review the progress of 50G-PON with a focus on the photonic components required to meet the stringent specifications for both the downstream and upstream transmission with symmetric data rate.

Session FIBER 03 - Colloquium on Optical Fiber Devices and Sensing Applications

Start: 15:00 End: 16:15
Location: Room C
Session Chair: *Qiang Wu, Northumbria University*

1 Peptide Functionalized Long Period Grating Optical Fibre Sensor for Antibody Measurement with Microfluidic System

Chenyang He, Alexander Tarr, Paddy Tighe, Serhiy Korposh, Stephen Morgan

Abstract: A long period grating (LPG) optical fibre sensor modified coated with an Immunoglobulin G (IgG)-binding peptide is reported. The IgG-binding peptide provides a controllable binding affinity towards IgG which is comparable to antibody-antigen interaction due to the non-covalent bonds of the peptide's amino acid enabling development of a reversible optical fibre immunosensor. A microfluidic system has been developed for reliable flow of liquid over the sensor.

2 Dual Parameter Simultaneous Sensing of Ammonia and Humidity Utilising Dye-Encapsulated Extrinsic Fabry-Pérot Interferometer

LiangLiang Liu, Serhiy Korposh, Stephen Morgan

Abstract: This work demonstrates a fiber optic sensing probe functionalized with a single-film for measuring two parameters: gaseous ammonia and humidity. The sensor is constructed with a dye (Tetraphenylporphyrin tetrasulfonic acid hydrate) encapsulated into a porous silica film dip-coated on the distal end of optical fiber forming an extrinsic Fabry-Pérot cavity. This approach combines two popular optical measurement techniques such as white light interferometry and colourimetry measurement in a single fiber and performs spectroscopic analysis of the cavity for dual sensing. Experimental results demonstrate that multiple attenuation bands appearing in the reflection spectrum consist of a mixture of dye absorption and white light interference with spatially resolved bands, allowing sensing of the two-parameter based on colourimetry shift and refractive index change, respectively. The corresponding attenuation bands shift independently in response to ammonia (range: 0-18 ppm) and humidity (0-100%) with negligible crosstalk. The sensor exhibits ~2 nm wavelength shift for 0.7 ppm of gaseous ammonia and a sensitivity of 0.4 nm/%RH for humidity measurement.

3 High Sensitivity Interferometric Refractive Index Sensor Based on Tapered Polarization-Maintaining Fiber

Long Chen, Kai Guo, Chen Jiang, Yuehui Ma, Yunqi Liu

Abstract: We proposed an ultra-sensitive refractive index sensor based on a tapered polarization-maintaining fiber Mach-Zehnder Interferometer using a CO2-laser heating and tapering system. The sensitivity of the sensor can be up to 7933.33 nm/RIU.

4 Delay-Insensitive Time Stretch Interrogation of Fiber Bragg Grating Sensors

Yue Feng, Yuanli Yue, Qiang Wu, Chao Wang

Abstract: Photonic time stretch (PTS) approach using ultrashort optical pulses has enabled ultrafast real-time interrogation of wavelength-modulated optical fiber sensors. It has been always assumed that dispersion induced wavelength-to-time mapping is unique and determinic such that the wavelength information of the sensor can be determined from its temporal position. However, random time shifts caused by fibre length changes or distance variations in remote sensing have been overlooked. In this paper, a novel delay-insensitive PTS-assisted ultrafast interrogation technique for remote fiber Bragg grating (FBG) sensors has been proposed and demonstrated. It is made possible by applying chirped microwave frequency encoding such that optical wavelength can be detected from the instantaneous microwave frequency of the encoded stretched pulse, eliminating the effect of random time shifts. The performance of the proposed interrogation system is elaborated by numerical simulation studies. Ultrafast interrogation of remotely placed FBG sensors has been demonstrated. Results verified that the system is immune from distance changes between the sensor and the interrogation reader. A high wavelength resolution of 0.0016nm and a 50 MHz detecting speed with the superior time-delay insensitive characteristic is realized.

5 Fibre Optics Biosensors for the Detection of Bacteria - a Review

Jomin Joy, Meng Zhang, Richard Binns, Richard Fu, Zabih Ghassemlooy, Qiang Wu

Abstract: Optical fiber Biosensing for bacteria detection is an emerging technology in the past two decades, which has advantages of high sensitivity, small size and capability for real time monitoring. In this paper, different types of optical fiber bacteria biosensors were classified and summarized.

Session FRONT-EDGE 04 - Enabling Technologies

Start: 16:30 End: 18:00
Location: Auditorium II
Session Chair: *Paulo P Monteiro, Universidade de Aveiro*

1 Wavelength Reconfigurable Point-To-Multipoint Fiber-Wireless Fronthaul with 10 Gb/s Traffic for Network Sharing Applications

Christos Vagionas, Ronis T. Maximidis, George Kalfas, Marios Gatzianas, Agapi Mesodiakaki, Amalia N. Miliou, Nikos Pleros

Abstract: A reconfigurable Fiber-Wireless fronthaul that can steer 4lambda-WDM IFoF channels with 4x 2.5 Gb/s data traffic of 16-QAM signals to V-band Phased Antenna Array using an AWGR as an all-passive any-to-any wavelength router is experimentally evaluated towards promoting the co-existence of multiple fronthaul streams of Mobile Network Operators/Tenants operating over a single, shared 5G C-RAN architecture, while simultaneously satisfying for the first time, the 5G Key Performance Indicator (KPI) requirement for a 10 Gb/s aggregate peak-data traffic capacity through FiWi mmWave/IFoF links based on Phased Array Antenna with RF beamsteering.

2 DFB Tuning Functions in Coherent PONs

Santiago Tabares, Josep Prat, Victor Polo, Roger Sole

Abstract: The use of Distributed FeedBack lasers for Passive Optical Networks requires specific architecture and appropriate algorithms for control and fine tuning to manage the spectrum. These algorithms can be implemented over simple single-mode lasers using thermal closed-loop with a control structure and 2x2 pre-equalization stage; the wavelength and optical power are tuned precisely with negligible oscillations for channels spaced 6.25GHz under an ultra-dense-wavelength-division-multiplexing scenario.

3 High-Sensitivity Receivers for Free-Space Optical Transmission Links

Peter A Andrekson

Abstract: We review sensitivity limitations of optical receivers used in long-haul FSO links and describe recent results using phase-sensitively pre-amplified receivers, with emphasis on cases where the received signals are very weak.

4 ICXT Characterization in WC-MCFs and Its Impact on the Performance of OOK-DD Systems

Adolfo Cartaxo, Tiago Alves, João Rebola

Abstract: The random evolution of the intercore crosstalk (ICXT) over time observed experimentally in weakly-coupled multicore fibers (WC-MCFs) is characterized and the correlation between the ICXT field components induced by multiple interfering cores is investigated. The impact of the ICXT on the outage probability of on-off keying direct-detection WC-MCF systems, with |skew x bit rate|«1 and |skew x bit rate|»1, is assessed as well. It is shown that the ICXT power induced by multiple interfering cores is adequately modelled by a chi-square distribution with four degrees of freedom. This means that the ICXT Gaussian field components are uncorrelated or weakly correlated. The measurements of the system performance show that, for the same outage probability, systems with |skew x bit rate|»1 present an additional ICXT tolerance of about 3 dB compared with systems with |skew x bit rate|«1.

5 Materials for Wide-Band Amplification

Hélène Carrere, Rajagopal Shyamala Joshya, Quentin Hochart, Cosimo Calo, Marie Xavier, Olivier Delorme, Andrea Balocchi, Arnaud Wilk

Abstract: The material gain of InGaAsP/InGaAsP quantum-well active layers is calculated, including tetragonal strain and confinement effects. For compressively strained structures, the calculated optical bandwidth reaches 150 nm. For structures under tensile strain, the optical bandwith reaches 110 nm with a polarization sensitivity which is lower than 1 dB between TE and TM emissions over the -3 dB optical bandwidth. Further enlargement of the optical bandwidth is expected by reducing the quantum well width.

6 Extending the reach of O-band transmission

Periklis Petropoulos

Abstract: The availability of bismuth-doped fibre amplifiers has the potential to expand the application space of transmission systems operating in the 1300-nm region. We review experimental demonstrations of high-speed amplified transmission at these wavelengths, and study the onset of dispersion-induced impairments in the O-band.

Session SS6 - Towards ML-Based Efficient and Secured 6G Networks

Start: 16:30 End: 18:00
Location: Room A
Session Chairs: *Sergio Barrachina-Muñoz, Centre Tecnològic Telecomunicacions Catalunya and Roberto Gonzalez, NEC Laboratories Europe*

1 AI-Assisted X-Haul in O-RAN Ecosystem

Panteleimon-Konstantinos Chartsias, Dimitrios S. Kritharidis, George Mourtzoukos, Ioannis Chochliouros, Alexandros Kostopoulos

Abstract: As more and more 5G networks are deployed worldwide, exploratory research has already started on 6G networks as a next-generation solution. Open RAN is an idea which enables a radical transformation towards 6G, introducing novel concepts such as disaggregation, virtualization, and Artificial Intelligence (AI) in the RAN. In this paper, following the O-RAN architectural innovation of the RAN Intelligent Controller (RIC) functional split, a two level software-defined fixed-mobile convergence architecture is introduced and analyzed. Furthermore, an evaluation of AI algorithms (e.g. for traffic prediction) is presented as part of the aforementioned architecture, with special focus on the transport network.

2 Cloud-Native 5G Experimental Platform with Over-The-Air Transmissions and End-To-End Monitoring

Sergio Barrachina-Muñoz, Miquel Payaró, Josep Mangues-Bafalluy

Abstract: 5G represents a revolutionary shift with respect to previous generations given its design centered on network softwarization. Within such a change of paradigm, cloud-native solutions are widely regarded as the future of vertical application development because of their enhanced flexibility and adaptability to complex and dynamic scenarios. In this context, we present an experimental framework with over-the-air transmissions that tackles two critical aspects for enhancing the lifecycle management of 5G and beyond networks: cloud-native deployments of 5G core network functions (NFs) and end-to-end monitoring. First, we deploy Open5GS and Prometheus-based monitoring as containerized network functions (CNFs) in a Kubernetes cluster spanning a multi-tier network with a multi-access edge computing (MEC) host. We then demonstrate the end-to-end monitoring system by showcasing via Grafana dashboards both infrastructure resources and radio metrics of two scenarios; one devoted to user plane function (UPF) re-selection and the other to user mobility.

3 Detect Resource Related Events in a Cloud-Edge Infrastructure Using Knowledge Graph Embeddings and Machine Learning

Katerina Mitropoulou, Panagiotis Kokkinos, Polyzois Soumplis, Emmanouel Varvarigos

Abstract: Edge and cloud computing infrastructures consist of multiple resources that may belong to different providers and are utilized in a shared manner by distributed applications for computing and storage purposes. Detecting events that affect the efficient operation of such infrastructures is a challenge and absolutely necessary for providing high quality cloud-edge services. In this work, we model cloud-edge infrastructures using knowledge graphs and use graph embeddings to transform the graphs into vectors. Then, traditional data-driven machine learning algorithms are used in order to detect anomaly events that relate to the infrastructure usage.

4 Prediphant: Short Term Heavy User Prediction

Davide Sanvito, Giuseppe Siracusano, Roberto Gonzalez, Roberto Bifulco

Abstract: Traffic prediction is of paramount importance for the correct management of network infrastructures. Most research efforts try to forecast the aggregated traffic over the network and over large time windows. In this work, we tackle the problem the other way around. That is, we predict the behaviour of individual users over short time windows. First, we investigate the contribution of the most data eager users to the global network traffic. We do it by analyzing network traces coming from several thousand real users. Then, we design a ML based technique that leverages past navigation patterns to predict sudden changes in the amount of resources consumed by each user. Finally, we evaluate our method using real data finding it is able to predict about 80% of the users that will rump up their network needs in most realistic scenarios.

5 Traffic Management in Cell-Free-Based 6G Networks

Irene Lidia Keramidi, John S Vardakas, Kostas Ramantas, Ioannis Moscholios, Christos Verikoukis

Abstract: 6G networks are envisioned as the key enabler for the intelligent information society of the next decade, targeting to achieve improved performance and satisfy demanding services and applications. This transition from the fifth generation requires novel and efficient approaches in the network design and network management domains that are able to achieve vital key performance indicators related to network densification, network throughput, positioning accuracy, energy efficiency. Cell-free networking is considered as a promising candidate for 6G, as it combines the advantages of distributed systems and massive number of antennas, thus being able to significantly improve the wireless transmission efficiency and provide better coverage. In this paper, we present a simulation study of a cell-free based 6G network that jointly considers the

utilization of the communication resources at the radio edge and at the fronthaul. The proposed study considers various techniques for the allocation of the resources at the two network segments, targeting to reduce the case where bandwidth compression (due to unavailability of resources) occur. The evaluation of the proposed solutions reveals that the application of a threshold policy may be beneficial for the end-users in terms of lower bandwidth compression rate.

6 Evaluation of Machine Learning Algorithms on Power Control of Massive MIMO Systems

Neda Ahmadi, Iosif Mporas, Pandelis Kourtessis, John Micheal Senior

Abstract: Power control (PC) plays a crucial role in massive multiple-input-multiple-output (m-MIMO) networks. Several heuristic algorithms, like the weighted mean square error (WMMSE) algorithm are used to optimise the PC. For these algorithms to perform the power control they require high computational power. In this paper, we address the problem through the application of machine learning (ML)-based algorithms as they can produce close to optimal solutions with a very low computational complexity. We propose the use of some machine learning (ML) methods such as deep neural network (DNN), deep Q-learning (DQL), support vector machine (SVM)-radial basis function (RBF), K-nearest neighbour (KNN), linear regression (LR), and decision tree (DT) to maximise the sum spectral efficiency (SE). The evaluation results demonstrate that the ML approaches can approximate near to the WMMSE based method.

Session SS7 - Massive MIMO and Millimeter-Wave Communications

Start: 16:30 End: 17:45
Location: Room B
Session Chair: *Adão Silva, Instituto de Telelcomunicações*

1 Low Complex Hybrid Precoder for Massive MU-MIMO mmWave Systems

Alvaro Ortega, Maykon Renan Pereira da Silva

Abstract: Wireless communication using millimeter-wave (mmWave) bands requires a large number of antennas with a reduced number of radio frequency chains. Hybrid precoding provides a viable solution to these requirements, reducing the manufacturing cost and power consumption while maintaining an operable performance at the price of increasing the computational complexity. This paper proposes a hybrid precoding method that computes the baseband beamformer in a less complex fashion. The considered low-dimensional digital precoder requires a matrix inversion operation, which is obtained via approximation through an iterative scheme based on the secant method. Exhaustive numerical results evidence that the less complex proposed hybrid precoders offer satisfactory spectral efficiency and BER performance in multiple scenarios.

2 Centralized Hybrid Equalization for Cell Free mMIMO mmWave Based Systems

Joumana Kassam, Daniel Castanheira, Adão Silva, Rui Dinis, Atílio Gameiro

Abstract: Cell-free massive multiple input multiple output (CF mMIMO) is one of the promising technologies for beyond 5G/6G wireless communications due to its advantages in overcoming the inter-cell interferences constraints in ultra-dense networks. In this paper, we propose a low-complexity analog precoder with a centralized hybrid analog-digital multi-user equalizer for millimeter-wave (mmWave) CF mMIMO systems. In the transmitter, a low-complexity analog precoder is applied based on the partial channel state information (CSI) knowledge, i.e., only the average angle-of-departure (AoD) information. While in the centralized hybrid receiver, the central unit (CU) handles all processing that requires access to the global CSI. Herein, the analog coefficients of the equalizer are obtained by minimizing the mean square error (MSE) between the transmit and receive signals using the weighted Frobenius norm as a metric, whereas an optimum linear MSE equalizer is used to get the digital part. We also compare the considered CF scenario with the small-cells (SCs) based one for different hybrid schemes. The results show that the proposed precoder combined with the hybrid equalizer can achieve very close results to a fully digital counterpart. Moreover, the performance of the considered CF scenario is higher than the SCs based one for all hybrid schemes.

3 New Formulations for Optimal User Coverage Using 5G Millimeter-Wave-Based Networks

Pablo Adasme, Sergio Cordero, Ismael Soto, Ali Dehghan Firoozabadi

Abstract: In this paper, we consider two optimization problems related to 5G millimeter wave (mmWave) networks. The first one consists of maximizing the number of covered users using a predefined number of base stations (BSs) while simultaneously minimizing the distances between users and BSs. Whereas the second one minimizes the total number of BSs required to cover all users in the network. Notice that mmWave technology has been conceived in the literature as one of the most promising techniques for 5G networks. However, there are still several issues to be addressed before this technology can be used massively in real-life networks. For example, mmWaves cannot penetrate walls easily and their path loss is high which reduces the transmission distances. We propose mixed-integer programming models to deal with these problems. Our models can solve instances with up to 100 BSs and 1000 users optimally. Our numerical results indicate that minimizing the distances between users and BSs and maximizing user coverage simultaneously leads to instances that are significantly harder to solve. Finally, we report the minimum number of BSs required to cover all users in the network together with the minimum radius that makes it possible.

4 Parametric Approximation to Optimal Averaging in Superimposed Training Schemes Under Realistic Time-Variant Channels

Ignasi Piqué Muntané, Maria Julia Fernandez-Getino Garcia

Abstract: Superimposed Training (ST) with orthogonal frequency division multiplexing (OFDM) scheme has become an attractive solution to meet the goals of the fifth generation (5G) of mobile communications, by improving the channel estimation performance, which is one of the main challenge in multiple input multiple output (MIMO) systems. This technique does not hinder the throughput, however, it introduces an intrinsic interference since the data and the reference symbols are sent together. In order to mitigate it, several studies propose a time averaging over several OFDM received symbols, where the optimal length of this averaging can be analytically computed by solving a transcendental equation. In this paper, this optimal averaging is approximated by a low complexity parametric approach based on a multiple linear regression model that inputs two parameters, the signal-to-noise ratio (SNR) and the relative speed between the transmitter and receiver. Results show that the approximated solutions give an error of 0.05% on average and 7% at most in terms of the provided mean square error (MSE) of the channel estimation.

5 Parallel Implementation of a Massive MIMO Linear Detector

Sayyed Shafivulla, Aaqib Patel, Mohammed Zafar Ali Khan

Abstract: Implementing the m-MIMO detectors and precoders requires a series of matrix-

vector multiplications. These multiplications typically have iterative forms which are suitable for serial implementation. Serial implementations impose a significant delay into the system, impacting the system's latency and making implementations a problem. This paper considers a recently proposed linear m-MIMO detector and presents an efficient parallel technique to compute the detector's estimation vector. We implement the computation on the Nvidia Tesla T4 graphics processing unit (GPU) with compute unified device architecture (CUDA) application programming interface using Google colab. Numerical and implementation results are presented to quantify the speedup of the proposed parallel algorithm's runtime as compared to existing parallel algorithms.

Session SS8 - UAV Communications: Energy Efficiency, Resource Management and Security

Start: 16:30 End: 17:45
Location: Room C
Session Chair: *Gordon Johnson, Kingston University*

1 Energy Aware Routing Protocol for Sparse Underwater Acoustic Wireless Sensor Network

Muhsin Hassanu

Abstract: Rapid changes in technological transformation have brought about changes for devices involved in network communication. The emergence of internet of underwater things (IoUT) has led to an autonomous monitoring of underwater environment using underwater devices. Underwater acoustic wireless sensor networks (UAWSNs) are widely used enabling underwater communication technology for (IoUT) as they support longer transmission range. However, suffer from certain limitations which consist of node mobility, multi path fading, propagation delay, limited bandwidth and sensor nodes limited battery. Sensor nodes involved in the communication process are battery dependent which makes it burdensome to replace or recharge. The communication procedure between these sensor nodes relies on routing. Network scale plays a role in energy conservation among sensor nodes by assessing the volume of communication to base station. As a result, this paper proposes an energy efficient routing protocol for sparse network using ad-hoc on-demand distance vector (AODV) routing protocol named as ADOV-sparse underwater acoustic routing protocol (AODV-SUARP). AODV-SUARP was simulated using Aquasim-NG for NS-3 against the conventional AODV and vector base forwarding (VBF) routing protocols. Simulation result shows AODV-SUARP outperforms AODV and VBF routing protocols in terms of energy consumption and packet received for different number of nodes.

2 UAV Energy Awareness Based on Network Communication Optimization and Power Efficient Trajectories

Georgios Fevgas, Thomas Lagkas, Vasilis Argyriou, Panagiotis Sarigiannidis

Abstract: The purpose of energy-efficient Coverage Path Planning (CPP) methods is to minimize energy consumption using multiple Unmanned Aerial Vehicles (UAVs) of the coverage area. In multiple UAVs systems, the network configuration plays a crucial role in the network's survivability and mission execution. However, the network's survivability and stability depend on the network's resources optimization. This paper presents a review of single or multiple UAV energy-efficient CPP methods. Furthermore, we discuss the network configurations of multiple UAVs systems. Likewise, we aim to present networks' energy optimization approaches and directions for future research.

3 Swarm Mobility Models and Impact of Link State Awareness in Ad Hoc Routing

George Amponis, Thomas Lagkas, Vasilis Argyriou, Ioannis Moscholios, Maria Zevgara, Savvas Ouzounidis, Panagiotis Sarigiannidis

Abstract: With the development of new communication models and the establishment of next-generation cellular communications, new applications have been enabled and new communication requirements have emerged. Flying ad hoc networks are pivotal in supporting this technological leap, and as such, resorting to application- and mobility-aware routing is a promising enabler of this emerging set of use cases. This paper discusses matters of swarm mobility modelling, types of applicable routing protocols, whilst aiming to correlate channel link state awareness with quality of service in different mobility scenarios. The results of this paper will help formulate new methodologies and best practices for ad hoc routing protocols, considering computational and communication quality demands.

4 Augmenting Images with a Mid-Processing Unit to Enhance Classification Accuracy

Gordon Johnson, Vasilis Argyriou, Christos Politis

Abstract: Expression recognition is a challenging task, in this paper we aim to improve upon the accuracy of an existing Machine Learning classification system by augmenting the images. The objective is to do this with no-retraining of the existing model and to see if the augmented images can provide support and benefit to the classification problem. This is done by using an Mid-Processing Unit to manipulate data from the first pass of the classifier to enhance the original image and to provide a better accuracy result overall. Three dimensional reduction algorithms have been explored as a method to augment the images, these include Principal Component Analysis, T-distributed Stochastic Neighbour Embedding, and Non-Negative Matrix Factorisation. In addition to this, Facial Landmarks where also explored as an additional data source. There was two phases to the testing 1. to identify which method combination would present the best accuracy improvement, and 2. to fine tune the applied weight to the original images. The final results showed that T-distributed Stochastic Neighbour Embedding in combination with a weight set to 0.024 achieved almost 1% increase in the existing classifier accuracy.

5 Unmanned Aerial Vehicle Positioning and User Equipment Power Allocation

João Martins, Carlos Henggeler Antunes, Marco A. C. Gomes, Vitor Silva, Rui Dinis

Abstract: In the near future, unmanned aerial vehicles (UAVs) will have enormous potential applications for next-generation wireless communication systems, in which they can collaborate to serve several user equipment (UE) for communication purposes. Disaster scenarios are a

relevant research topic, in which UAVs can aid establishing connections in circumstances where base stations (BS) may be inoperative. The resulting UAV positioning affects the overall spectral efficiency (SE) in each UAV-UE link. Moreover, UEs energy consumption must be optimized since the finite amount of energy available is one of the most significant limitations of these devices. Therefore, it is essential to determine the lowest power consumption necessary to guarantee a minimum SE throughput in a disaster location. In this paper, we investigate a cooperative Meta-Heuristic (MH) optimization algorithm for both the UAVs and UEs. We propose two parallel optimization approaches: one is the UAV search position process to find the best possible location to serve its pre-allocated UEs; the other is finding the lowest possible uplink (UL) power values for each user's equipment. The preliminary results show that the Differential Evolution (DE) algorithm reaches good quality solutions in acceptable computation runtime.

Day 3 - 22 July 2022

Plenary Talk 05

Start: 09:00 **End:** 10:00
Location: Auditorium II
Session Chairs: *Carmo Medeiros, Institute of Telecomunications, University of Coimbra and Wai Pang Ng, Northumbria University*

P Recent Advances in Machine Learning for Signal and Image Processing

Miguel Rodrigues
University College of London

Abstract: This talk will overview recent advances in the area of machine learning - including deep learning - for signal and image processing. It will also overview algorithm unfolding techniques that are currently delivering state of the art results in a wide range of challenges, including image reconstruction, image super-resolution, and various others.

Session OWC 11 - Under Water Optical Wireless Communications

Start: 10:00 End: 10:45
Location: Auditorium II
Session Chairs: *Shivani Rajendra Teli, Czech Technical University and Othman Isam Younus, Northumbria University*

1 A Novel Frame Synchronization Scheme for Underwater Optical Wireless Communication with Reduced Complexity

Yu Zhu, Nuo Huang, Weijie Liu, Shangbin Li, Zhengyuan Xu

Abstract: In this paper, we propose a novel frame synchronization method for underwater optical wireless communication (UOWC) systems with on-off keying (OOK) modulation. Considering the frame structure that sync word is periodically embedded in the bitstream, the proposed method jointly estimates the sync word position, data sequence and channel gain based on the received signals in the period of a frame length. To reduce the implementation complexity, the original estimation problem is further simplified by utilizing the properties of OOK transmission. Simulation and experimental results both demonstrate the superiority of the proposed frame synchronization method over the correlation method. Specifically, experimental results show that the proposed method yields an optical signal-to-noise ratio (SNR) gain of at least 1.5 dB over the correlation method under dynamic channel with bubbles.

2 Performance of Uplink Underwater Optical Wireless Communications in the Presence of Random Sea Surface

Jianming Wang, Sujan Rajbhandari, Wasiu O. Popoola

Abstract: This paper studies the effects of the random sea surface on an up-link underwater optical wireless communication (UOWC) system. Both light-emitting diode (LED) and laser diode (LD)-based links are considered under the influence of the 3-dimensional random motion of the sea surface. The simplified form of beam spread function (BSF) is used to analyse the performance of the LD-based link while the Lambertian model is used for the LED-based link. Performance deteriorations caused by sea surface motion are estimated.

3 Path Selection for Relay-Assisted Underwater Visible Light Communication Systems

Mohammed Elamassie, Murat Uysal

Abstract: In this paper, we consider underwater visible light communications (UVLC) system

with M parallel relaying paths where each path has N decode-and-forward (DF) relays. One-path out of M paths will be selected for transmission. Considering the practical cases where selecting the best path is not always possible due to several reasons such as the effect of noise on the estimation of the best source and feedback error, we consider the case of mth best path selection for transmission. Assuming lognormal (LN) turbulence channels, we derive a closed-form expression for the system's outage probability. We then used our derived closed-form outage probability for investigating the so-called incremental diversity order (IDO).

Session OWC 12 - Positioning and Localization Systems

Start: 10:00 End: 10:45
Location: Room A
Session Chair: *Pedro Fonseca, University of Aveiro*

1 On the Performance of Angular Diversity Receivers in Underground Mining VLC Systems

Pablo Palacios Játiva, Cesar Azurdia, David Zabala-Blanco, Ismael Soto, Muhammad Ijaz, Diego F. Carrera, Sunday Cookey Ekpo

Abstract: Visible Light Communications (VLC) have generated great interest in the scientific community in the last five years due to their great adaptation to harsh environments. Among the scenarios that can benefit from the advantages of VLC systems are Underground Mining (UM) tunnels. However, the physical phenomena and the irregularity of this environment present a challenge for the implementation of the systems called UM-VLC. Therefore, it is important to research and develop practical solutions that improve the performance of these systems in the UM scenario and verify their efficiency. Under this context, in this article we propose the implementation of pyramidal and hemi-dodecahedral Angle Diversity Receivers (ADRs) in the reception stage of a UM-VLC system. These solutions, along with the Maximum Ratio Combining (MRC) signal selection scheme, are evaluated and compared in terms of User Data Rate (UDR) and Cumulative Distribution Function (CDF) with respect to the Signal-to-Interference-plus-Noise Ratio (SINR). The numerical results obtained through computational simulations show that the hemi-dodecahedral ADR outperforms the pyramidal ADR in terms of the evaluated metrics.

2 Investigation of Indoor Atmospheric Attenuation in Visible Light Positioning for Industrial Applications

Vinson Javiero, Muhammad Ijaz, Sunday Cookey Ekpo, Bamidele Adebisi, Chen Chen, Pablo Palacios Játiva, Cesar Azurdia, Ismael Soto, Mohammad-Ali Khalighi

Abstract: In the recent decade, visible light communication (VLC) technology has extensively researched and implemented for numerous applications. Indoor visible light positioning (VLP) is just one of many applications for this technology. The transmission medium for indoor VLP systems for industrial environments could not be clear air. The industrial environments could be made of many different particles and fumes due to different temperatures including smoke particles, oil vapours, water mist and or industrial fumes. This work investigates the indoor atmospheric attenuation on the performance of the VLP for industrial applications. The VLP is achieved using a trilateration indoor positioning based on the Cayley-Menger-Determinant (CMD). The positioning method uses optical received signal strength (RSS) to estimate the drone's position with and without the presence of indoor atmospheric attenuations. Smoke and

fog effects for the indoor atmospheric attenuations have been considered for visibility (V) ranging from 0.015 km to 1 km. The results show that the position error increases from an average value of 5.73 cm without smoke and fog attenuation to 28.41 cm and 29.94 cm with smoke and fog attenuation. Furthermore, there is slightly higher received power in smoke attenuation as compared to fog in the same visibility range.

3 Object Tracking in an Indoor Scenario: Potential for Centimeter Accuracy with LiFi

Sepideh Mohammadi Kouhini, Ziyan Ma, Christoph Kottke, Sreelal Maravanchery Mana, Ronald Freund, Volker Jungnickel

Abstract: Localization in indoor scenarios is difficult based on radio technologies, due to fading and the dominant multipath propagation. Optical wireless technology also denoted as LiFi, propagates mostly via the line-of-sight. Therefore, it has the potential to provide the required centimeter accuracy for indoor Internet-of-Things applications. In this paper, we consider positioning as an extra service offered by the LiFi communication system. Our vision is to detect the required location of automatic guided vehicles, intelligent transport systems, and mobile assembly units in an industrial environment, by using the same hardware also used for wireless communication. Our proposal is based on time-of-flight measurements. We reuse the physical layer from the ITU-T recommendation G.9991 for LiFi for ranging and subsequent trilateration. In this paper, we have further developed this approach towards continuous object tracking and evaluated the accuracy of the 3D position detection in an indoor environment. We observe, that the results depend critically on the layout of the LiFi cell. Moreover, we demonstrate that the time-of-flight technique allows object tracking at a speed of 1 point / second with an average accuracy of 3 cm in each dimension. The proposed scheme is promising for future real-time implementation and has a high potential for future Internet-of-Things applications.

Session FRONT-EDGE 05 - Topologies, Networking, Traffic, Architectures

Start: 10:00 End: 11:00
Location: Room B
Session Chair: *Carla Raffaelli, University of Bologna*

1 SDN Control of Packet-Optical Edge Network Nodes

Emilio Riccardi, Davide Scano

Abstract: This paper presents and discusses two candidate solutions to efficiently control packet-optical nodes equipped with coherent pluggable modules. The first one is based on join management by two SDN controllers of the nodes, while the second solution relies on hierarchy of controllers.

2 Datacenter in the City: An Overlay Network for Serving Intra-City Traffic Between "Metro Islands"

Panagiotis Kokkinos, Polyzois Soumplis

Abstract: The computing and networking infrastructures that operate inside the city boundaries have started to attract the research interest. Future applications' requirements will only be served if processing and storage is performed locally, which will increase the number of traffic flows between communicating parties that lie inside the city. Furthermore "local" mini-data centers are placed closer to the user. However, modifications to the current metropolitan network architecture, which is organized into "metro islands" and the respective resource allocation mechanisms are required. In this work, we propose the Datacenter in the City architecture to serve the intra-city traffic. The proposed solution makes use of an overlay network with pre-reserved capacity that operates on top of the "metro islands" to serve the high priority traffic in a way similar to the way highways are used to decrease traffic congestion in the city center. The proposed architecture is viewed both from technological and from design and operation aspects. A resource allocation mechanism is presented that decides on the traffic and the respective workload that will be served locally withing the "metro islands" or that will utilize the overlay network so as to be served by other computing and storage facilities inside the same city.

3 Access-Metro Versatile Coherent Dual Optical Network Providing Integrated Services

Josep Segarra, Victor Polo, Miquel Masanas, Josep Prat

Abstract: A novel access-metro network architecture based on lightpath flows, using coherent transmissions, supporting numerous passive optical networks (PONs), and integrating multiple services, including 4G/5G/6G mobile networks, is presented. The lightpaths flows are flexibly assigned in an ultra-dense wavelength division multiplexing PON (UDWDM-PON) with dynamic bandwidth allocation. The mobile networks are integrated in a cloud radio access network (C-RAN), which provides reconfigurable capabilities between the remote radio heads (RRHs) near the users' premises and the baseband units (BBUs) located at a centralized central office (CO) in the metro side. The whole access-metro proposal incorporates the PONs, including the C-RAN services, in a versatile coherent dual optical network (VERSONET) ring architecture; enabling resilience, real-time centralized control, provisioning and also administration and maintenance (OAM) functions.

4 Transparent and Fast Reconfigurable Optical Network with Edge Computing Nodes for Beyond 5G Applications

Henrique Santana, Bitao Pan, Krisitf Prifti, Rafael Kraemer, Ali Mefleh, Nicola Calabretta

Abstract: To fulfil stringent latency requirements of time-sensitive applications in 5G and beyond networks, data has to be processed in a decentralized way. The Edge Cloud Network is composed of computational resources placed at most at tens of kilometers far from the sources of the data flows they need to process. Besides the physical proximity, nanosecond-scale reconfiguration time of optical switches and a fast control of the optical networks are also required to guarantee dynamicity with latencies on the order of tens of microseconds. Moreover, photonic switches will enable transparent by pass of nodes reducing costly and power hungry and format dependent optical to electrical to optical interfaces as well as large jitter in electrical switches. In this work, we propose an Edge Cloud network composed of a metro-access ring and optically switched edge data center. SOA-based ROADMs are used in the ring for fast add/drop of wavelengths. The edge data center is composed of top-of-rack switches interconnected via an SOA-based optical switch. A supervisory channel is used by the network nodes to exchange control packets in a time-slotted synchronous fashion, and FPGA-based controllers guarantee nanosecond-scale reconfiguration decisions.

Session OWC 13 - System Design

Start: 11:30 End: 12:30
Location: Auditorium II
Session Chair: *Amany Kassem, University College London*

1 Ultra-Broadband Optical Wavelength-Conversion Using Nonlinear Multi-Modal Optical Waveguides

Norbert Hanik, Tasnad Kernetzky, Yizhao Jia, Ulrike Höfler, Ronald Freund, Colja Schubert, Isaac Sackey, Gregor Ronniger, Lars Zimmermann

Abstract: Ultra-Broadband Wavelength Conversion is one of the key issues of future high-capacity, flexible optical networks. Using optimized Multi-Modal Optical Waveguides with high cubic nonlinearity, broadband wavelength conversion between extreme optical wavelength-bands has been achieved. In this contribution, the physical background of ultra-broadband optical wavelength-conversion in multi-modal optical waveguides, and methods to model and optimize their functionality, are outlined. Finally, experimental results are discussed.

2 Demonstration of Optical Wireless Communications System Using a Software Defined Ecosystem

Zun Htay, Carlos Guerra-Yánez, Bharath Karanam, Zabih Ghassemlooy, Stanislav Zvanovec, Mohammad-Ali Khalighi, Mojtaba Mansour Abadi

Abstract: In this paper, we experimentally demonstrate the implementation of an optical wireless communication system in a software defined radio platform using GNU radio ecosystem and verify the link performance in terms of the bandwidth and jitter by changing the interpolation parameters in the software domain. We show that, the software defined optical system provides high reconfigurability and can be easily implemented without the need to change the architecture of the hardware, providing a real-time signal based system, which is highly desirable.

3 Performance of MMSE-LE in 2 Gbaud/s Single Carrier Visible Light Communication Using PAM-2

Flávio André Nogueira Sampaio, Tadeu Ferreira, Luiz Anet Neto, Andrés Pablo López Barbero, Maria Medeiros, Vinicius Nunes Henrique Silva

Abstract: A Visible Light Communication system (VLC) based on Pulse Amplitude Modulation (PAM-2) with equalisation of low-complexity is presented. The VLC system consists of a transmission chain with an off-the-shelf 520 nm Laser Diode (LD), whose distance from the

photodiode at the receiver is 1.8m. A Minimum Mean Square Linear Equalisation (MMSE-LE) with 16 taps enables communication to be performed at a baud rate of 2 Gbaud/s with a measured Bit Error Rate (BER) above the VLC Forward Error Correction (FEC) threshold. Digital Signal Processing (DSP) was performed in offline mode with MATLAB algorithm. Through the study carried out, it is possible to verify how much linear equalisation can compensate for the distortions of the transmission channel through the measured eye diagrams as well as the number of MMSE-LE taps to obtain optimised MMSE-LE performances and increase the capacity of the VLC channel with PAM-2.

4 Single-Mode Fiber Coupling Based on Defocus and Raster Scanning

Yixun Xiang, Xianqing Jin, Nuo Huang, Chen Gong

Abstract: For optical wireless communication, the laser needs to be accurately incident into the single-mode fiber (SMF) and further propagates in the fiber. However, the core diameter of SMF is generally about 10 microns, and any slight deviation will reduce the power coupled to the fiber end. To solve this issue, we propose a defocus method to increase the tolerance of deviation between the fiber core and coupling spot center. Then, a spot search method based on raster scanning is proposed to further increase the tolerance of deviation. In order to verify the defocus method, we adopt the pattern search method (PSM) to restore the alignment under a medium offset. Then, we propose a continuous variable hill-climbing (CVHC) method combined with raster scanning to restore alignment under a large offset. Both simulation and experimental results demonstrate the effectiveness of the proposed approach under medium and large offsets.

Session FRONT-EDGE 06 - Topologies, Networking, Traffic, Architectures

Start: 11:30 End: 12:45
Location: Room A
Session Chair: *Emilio Riccardi, Telecom Italia Lab*

1 Traffic Monitoring and Analytics Framework for Optical Access Networks

Behnam Shariati, Geronimo Bergk, Pooyan Safari, Mihail Balanici, Johannes K. Fischer, Ronald Freund

Abstract: This paper presents a Traffic Monitoring and Analytics (TMA) framework for optical access networks and defines the requirements and Key Performance Indicators (KPI) governing the telemetry collection, brokering, and streaming workflow as well as storage and computing resources of such a framework. Moreover, it introduces the concept of telecom data ownership and explores its impact on the realization of such a framework, primarily for the cases where equipment from multiple vendors co-exist in the operator networks. Eventually, considering the underlying requirements and the desired specifications, it presents several architectures for the realization of a TMA framework.

2 Cost, Power Consumption and Performance Analysis in SDM ROADM Architectures for Uncoupled Spatial Channels

Marco Q Silva, João Rebola, Luís Gonçalo Cancela

Abstract: Currently optical networks are reaching their maximum transport capacity. Several solutions, in particular, space division multiplexing (SDM) can be used to overcome this capacity limit. To use SDM, the reconfigurable optical add/drop multiplexers (ROADMs) need to be adapted to support this multiplexing. In this work, four switching strategies used in SDM ROADMs and the respective SDM ROADM architectures to implement these strategies are explained and analyzed, for uncoupled scenarios, in terms of cost and power consumption. The impact of the physical layer impairments (PLIs), namely, amplified spontaneous emission noise, non-linear interference, passband narrowing due to optical filtering and in-band crosstalk is also assessed, considering a cascade of SDM ROADMs with spatial and spatial-wavelength switching granularities. The in-band crosstalk in networks with a single spatial channel or in a SDM network with the ROADM architecture with spatial granularity has an insignificant impact, but in a SDM network with spatial wavelength granularity can lead to an OSNR penalty of around 2 dB, when the number of spatial channels is high. The other PLIs have similar impacts in all networks studied.

3 Reliable Slicing in Optical Metro Networks with Reconfigurable Backup Resources

Carla Raffaelli, Elisabetta Amato, Paolo Monti, Federico Tonini

Abstract: Network slicing enables resource sharing in high capacity network infrastructures. To support network flexibility in relation to dynamic application scenarios, slice configuration needs changes over time to maintain optimization in resource usage and meet performance constraints. Emerging services like autonomous driving or industrial contexts require critical low latency and high reliability referred in 5G context as the Ultra Reliable Low Latency Communications (URLLC) service introduced by 5G. With reference to this class of services this paper introduces a methodology to manage slice dynamics in network operation with limited complexity algorithm while maintaining optimal resource assignment. Simulation results shown how slice dynamics impact on performance in the presence of different reliability schemes. In particular the shared protection scheme is shown to perform remarkably better that the dedicated protection one and allows a viable approach to dynamic resource management.

4 Machine Learning Resource Optimization Enabled by Cross Layer Monitoring

Dimitrios Uzunidis, Panagiotis Karkazis, Eleni Aikaterini Leligkoy

Abstract: In this paper, we introduce a novel architecture and its open-source implementation that exploits the monitoring data from heterogeneous resources and uses them to train machine learning models, which can be used for dynamic resource management optimization. The existence of such a solution is extremely important for Service Providers (SP) as it can lead to the optimal use of their physical and virtual infrastructures avoiding potential waste of resources due to over-design while at the same time it can ensure that the required Quality of Service (QoS) levels are met. The proposed solution is validated in two real-life services showing very good accuracy in predicting the required resources in both cases for a large number of operational scenarios.