UNIVERSITÀ DEGLI STUDI DI PALERMO

Scheda 7

TITOLO DI DOTTORATO (in italiano):
INFORMATION AND COMMUNICATION TECHNOLOGIES (INTERNAZIONALE)

TITOLO DI DOTTORATO (in inglese):
INFORMATION AND COMMUNICATION TECHNOLOGIES

AREE CUN
01- Scienze matematiche e informatiche
02 - Scienze fisiche
03 - Scienze chimiche
08 - Ingegneria civile ed architettura
09 - Ingegneria industriale e dell'informazione

COORDINATORE
Prof.ssa Ilenia Tinnirello

SEDE DEL DOTTORATO
Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici (DEIM)
Università degli Studi di PALERMO

TEMATICHE DI RICERCA

ICT for smart communities

- Wireless software defined networks,
- Centralized Radio Access Network (RAN)/Cloud RAN
- Emerging Wireless Technologies
- Internet of things
- Advanced bio-electromagnetic numerical modelling and ICT for human brain research
- Unmanned Aerial Vehicles/ Unmanned Ground Vehicles cooperation for object manipulation
- ICT for smart cities based on connection of information, resources and cycles for a new intelligent urban metabolism
- Big data for smart urbanism and healthcare
- Robot Consciousness

KET for smart communities

- Terahertz quantum cryptography
- Optical source for the generation of quantum cluster states
- Novel Nanoplasmonic Devices for Spectroscopy and Nonlinear Optics
- Development of biodegradable microfluidic chips from Poly-lactic acid for clinical point-of-care applications
- Control Strategies for Nonlinear Systems subject to Constraints
- Advanced light management for high efficiency solar cells

Descrizione dettagliata delle tematiche di ricerca

ICT for smart communities

WIRELESS SOFTWARE DEFINED NETWORKS

The concept of software defined networks has attracted many research interests in the last years, due to the possibility to work on vendor-independent abstractions and configuration interfaces of network nodes, and centralized views of the network which simplify network configuration. The application of these principle to wireless networks is still not

consolidated, because of different technical problems: i) radio nodes cannot be considered as simple forwarding elements, being the concept of wireless links and network topology different from the wired case and affected by interference and mobility; ii) radio control networks, for infrastructure-less sensor or ad-hoc networks are not reliable and require to deal with innovative forms of control models and information aggregation. Therefore, it is interesting to investigate on radio programming models, network-level abstractions, context-aware intelligence, centralized/distributed tradeoffs for resource allocations, etc.

CENTRALIZED RADIO ACCESS NETWORK (RAN)/CLOUD RAN

5G networks will feature enhanced intelligence (e.g. multi-cell coordination) and flexibility. Some advanced functionalities are already deployed in 4G networks (LTE-A), as the use of larger frequency bands and cell densification, but future 5G networks are expected to ultimately boost Radio-Access-Network (RAN) performance using centralized coordination, as in CoMP (Coordinated Multi-Point). Centralized coordination will be enabled by the new paradigm of Centralized RAN (C-RAN), which requires to face several technical aspects, according to the mid-haul/backhaul network capacity, among which: i) optimized design of 5G access/aggregation networks; ii) optimized functional mappings between base station controllers (BBU) and radio transceivers (RRH); iii) inter-technology coordination of heterogeneous access network

EMERGING WIRELESS TECHNOLOGIES

Towards the 5G era, new technologies have been designed for dealing with a better use of scarce spectrum resources and energy, according to the specific application and traffic scenarios. Among these technologies, sub-GHz networks for low-energy long distance links, mmwave networks with programmable antennas for high-bandwidth links, full-duplex radio, agile radio, and so on, are proposing specific advances on the physical layer capabilities, that are often not fully exploited by the higher layers protocols and especially by the MAC protocols.

INTERNET OF THINGS

Connected smart objects have invaded our everyday life across multiple domains, e.g. home with automation solutions, assisted living with sensors and wearables to monitor personal activities, smart transportation and environmental monitoring. IoT is evolving around a plethora of vertically isolated platforms, each specifically suited to given scenarios and often adopting non-standard, sometimes fully proprietary, protocols to control the variety of sensors, actuators and communication elements. Important research aspects include: unified and secure access to physical and virtualized IoT resources; hierarchical and orchestrated discovery and control across multiple IoT platforms; federation of IoT controllers and resources for cooperative sensing/actuation tasks; seamless roaming of smart objects across smart spaces.

ADVANCED BIO-ELECTROMAGNETIC NUMERICAL MODELLING AND ICT FOR HUMAN BRAIN RESEARCH

The research aims to contribute to the identification and definition of advanced methodological approaches in order to obtain, in a non-invasive way, a considerable improvement of the information about the human brain activity. This information is essential for understanding both the working mechanisms related to the structure of the brain and the nature of many diseases. Competences from different fields (applied mathematics, engineering, physics and medicine) are required to develop innovative methodologies for a new generation of fully non-invasive brain activity investigation systems based on magnetoencephalography (MEG) and electroencephalography (EEG). Possible objectives are to implement innovative meshfree numerical approaches that outperforms the current state-of-the-art M/EEG solvers based on boundary element method (BEM), improving their performance and the neuroimaging research field. Additional objective could be to set up an inexpensive, new, wireless, digital platform with an improved signal-to-noise ratio (SNR).

UNMANNED AERIAL VEHICLES/ UNMANNED GROUND VEHICLES COOPERATION FOR OBJECT MANIPULATION

Unmanned Aerial Vehicles (UAVs), used in combination with Unmanned Ground Vehicles (UGVs), as aerial manipulator systems have recently drawn the attention of several researchers around the world. Early experiments conducted in controlled lab environments have demonstrated the transportation (control of the position) and manipulation (control of the position and orientation) of objects through UAVs. Most of the works on this subject concern the transportation of objects through single, including grasping, hovering capture, load stability. For what it concerns the manipulation of objects through multiple UAVs only preliminary results have been achieved. This research aims at studying and designing robust and adaptive control strategies, taking into account of the system model uncertainties and actuator

saturation.

ICT FOR SMART CITIES BASED ON CONNECTION OF INFORMATION, RESOURCES AND CYCLES FOR A NEW INTELLIGENT URBAN METABOLISM

City is the place in which resources from the countryside (with low-level carbon emission and high capacity of carbon capture) are transformed in resources with high level of value-added information.
In the city, we can see a community life that builds fruitful relationships, generates fertile synapses, by producing new economies and by accelerating innovation.
So, if social, technological, cultural innovation is a fertile connection of elements, and urbanism needs to be an effective connection enabler, then this research topic works about the concept of human smart city as system of places and services, data and information, local and global economic resources, social sensors and actuators, in a permanent human and urban metabolism, based on circadian rhythm of cities and citizens.
In this research topic, we intend to study the boundary line among smart city hi-technology, urban policies and planning and social cohesion, in order to define the singularity of a new possible generation of human smart cities. We also plan to create friendly platforms based on dashboards, apps and other digital tools for the improvement of social relationships among citizens, events participation, learning and education.

BIG DATA FOR SMART URBANISM AND HEALTHCARE

In the past decades a data explosion has occurred causing the new phenomena of "big data", that is, the generation of enormous, varied, dynamic, and interconnected datasets coming from different contexts.
Cities and citizens play a key role in the production of such data, that can be used themselves to re-imagine and regulate the urban life, by transforming the knowledge and governance of cities in order to provide much more sophisticated, wider-scale, finer-grained, real-time understanding and control of urbanity. Suitable data modelling, organization and management are needed to this aim, and the usage of advanced technologies is required as well.
In this scenario, frameworks such as Apache Hadoop and Spark, NoSQL databases and Data Warehousing, became the standard de facto in order to guarantee efficiency and to allow the processing of huge amounts of data. On the other hand, data compression plays a fundamental role, since for many applications data need to be processed in real time.
We intend to design efficient algorithms and novel methodologies for the analysis of big data in the context of smart urbanism and healthcare, including the management of complex networks and large sets of sequences, the proposal of advanced techniques for data integration and the performance evaluation of existing/novel algorithms when they are implemented by using big data technologies.

ROBOT CONSCIOUSNESS

The primary objective of the research field is aimed at creating a new generation of conscious robots with powerful perceptual and cognitive skills, able to learn by interacting with people and with the external environment and driven by motivations and emotions. The main research areas consist in: robot models of consciousness inspired from Neuroscience and Cognitive Science; robot models of emotions and motivations; perception and actuator systems for conscious robots; evaluation of trust in conscious robots in everyday life; formal methodologies for conscious robots software; assessments methods of conscious robots.

KET for smart communities

TERAHERTZ QUANTUM CRYPTOGRAPHY

Quantum cryptography is the science of exploiting quantum mechanical properties to perform cryptographic tasks. The best known example of quantum cryptography is quantum key distribution which offers an information-theoretically secure solution to the key exchange problem. This research topic intend to combine two actuals “hot topics” namely terahertz (THz) technology and quantum photonics, with the ambitious goal of extending the concept of quantum cryptography (actually mostly applied to standard telecommunication wavelengths) to the THz region. In this case we intend to realize for the first time continuous-variable quantum cryptography protocols suitable for secure high-speed THz wireless communications.

OPTICAL SOURCE FOR THE GENERATION OF QUANTUM CLUSTER STATES

Complex quantum states (more specifically a special kind of multipartite entangled quantum states – so-called cluster states) form the basis for the measurement-based model for quantum computation and for the related topological approach to quantum error correction. These cluster states are composed of more than two quantum bits, hereinafter referred to as qubits, where at least one of the qubits is entangled with more than one of the other qubits. The measurement-based quantum computation model implements algorithms using these cluster states, by means of just single-qubit measurements. If the qubits are implemented using quantum optics, i.e. electromagnetic radiation or photons, they are referred to as "optical cluster states". In this research topic, we intend to realize non-classical optical sources for the generation of multi-correlated and multi-entangled quantum optical cluster states in third-order nonlinear resonant structures.

NOVEL NANOPLASMONIC DEVICES FOR SPECTROSCOPY AND NONLINEAR OPTICS

The research deals with the development of novel nanoplasmonic concepts and devices. In particular, we intend to shed some light on the use of nanostructures for assisting (i) direct-absorption spectroscopy (with a special interest for the mid-infrared and terahertz spectral regions) and (ii) nonlinear optics. We envision applications in sensors with increased sensitivity and nanophotonic devices for information processing, capable of routing, shaping, frequency-converting pulses and delivering them to the nanoscale. The successful candidate will investigate new schemes and design novel nanophotonic tools, making use of numerical simulations. Furthermore, he/she will characterize the spectroscopic response of these kinds of devices, by means of frequency- and time-resolved optical techniques.

DEVELOPMENT OF BIODEGRADABLE MICROFLUIDIC CHIPS FROM POLY-LACTIC ACID FOR CLINICAL POINT-OF-CARE APPLICATIONS

The advent of disposable medical consumable items, which offers the safety of zero-contamination possibility, without the need for disinfection, has participated in the recent increase of medical plastic waste. With the development of personalized medicine technologies, namely new point-of care diagnostic tests made of disposable polymeric plastic cartridges, the volume of plastic waste is going to increase dramatically. To address this issue, the candidate will explore the manufacturing of disposable microfluidic chips for clinical point-of-care applications using environmentally-friendly polymeric mixtures with minimal pollutant release during combustion.

CONTROL STRATEGIES FOR NONLINEAR SYSTEMS SUBJECT TO CONSTRAINTS

Controlling real plants not only involves asymptotic stability requirements, but also that controlled plants satisfy a set of constraints at all times during their motion. Several schemes have been proposed in the literature to deal with such an issue, mainly consisting in Model Predictive Control (MPC) architectures. Alternative, less performing than MPC solutions, but much more attractive for practitioners willing to preserve existing controllers and/or to limit issues related with computational effort, should be devised. This research aims at defining and developing contro schemes for reference/command governors allowing existing control systems to be preserved, while ensuring that constraints are satisfied.

ADVANCED LIGHT MANAGEMENT FOR HIGH EFFICIENCY SOLAR CELLS

Recent advances in nanophotonics provide tools to manipulate the flow of light in solar cells. Light trapping allows us to use thinner cells, thereby reducing defect recombination and improving carrier collection, short circuit current and open circuit voltage. The candidate will implement an optical design for a tandem device. The main requirements for this design are: 1) Front-side light in-coupling and transparent electrodes for the top cell. 2) Intermediate wavelength-selective mirror with Lambertian reflection of visible light into the top cell and a sharp reflection cut-off for long-wavelength photons at the band edge of the top cell. 3) Front-side in-coupling and backreflector for the bottom cell, optimized for infrared light. The design will be led by extensive optical and electrical modelling and the results will guide the experimental realization of the photonic structures in the solar cells developed

CURRICULA italiano ed inglese

1. ICT for smart communities
2. KET for smart communities

TITOLI DI ACCESSO

(Per gli studenti stranieri il collegio si pronuncerà sull'equipollenza del titolo conseguito all'estero

per l'accesso al corso di dottorato)

Classi di Laurea:
LM-17 Fisica; LM-18 Informatica; LM-21 Ingegneria biomedica; LM-22 Ingegneria chimica; LM-25 Ingegneria dell'automazione; LM-26 Ingegneria della sicurezza; LM-27 Ingegneria delle telecomunicazioni; LM-28 Ingegneria elettrica; LM-29 Ingegneria elettronica; LM-32 Ingegneria informatica; LM-40 Matematica; LM-48 Pianificazione territoriale urbanistica e ambientale; LM-53 Scienza e ingegneria dei materiali; LM-54 Scienze chimiche; LM-66 Sicurezza informatica; 20/S (specialistiche in fisica); 23/S (specialistiche in informatica); 26/S (specialistiche in ingegneria biomedica); 27/S (specialistiche in ingegneria chimica), 29/S (specialistiche in ingegneria dell'automazione); 30/S (specialistiche in ingegneria delle telecomunicazioni); 31/S (specialistiche in ingegneria elettrica); 32/S (specialistiche in ingegneria elettronica); 35/S (specialistiche in ingegneria informatica); 45/S (specialistiche in matematica); 61/S (specialistiche in scienza e ingegneria dei materiali); 62/S (specialistiche in scienze chimiche)

Lauree v.o:
Per l'equipollenza delle "Classi di Lauree" del "Vecchio Ordinamento", consultare il sito del ministero: http://hubmiur.pubblica.istruzione.it/web/universita/equipollenze-titoli

PAGINA WEB DEL DOTTORATO

http://portale.unipa.it/dipartimenti/deim/dottorati/informationandcommunicationtechnologiesinconvenzioneconcnreavenspluss.r.l./obiettivi.html

POSTI DISPONIBILI

Totale posti con borsa	Posti con borsa riservati a laureati all'estero	**Totale posti senza borsa**	**Totale posti**
5 **di cui 4 borse finanz. 50% UNIPA e 50% INRS**	2	**1**	**6**

Il Dottorato internazionale in *Information and Communication Technologies* è realizzato in convenzione con l'*Institut National de la Recherche Scientifique* (INRS) del Canada, con l'Università libera di Bruxelles e con l'Univerisità Heriot-Watt di Edinburgo.

Per quel che riguarda il percorso a doppio titolo con l'istituto canadese INRS, saranno finanziati dall'INRS e dall'Università degli studi di Palermo (UNIPA) 4 posti con borsa in co-tutela per l'intera durata del corso di Dottorato a doppio titolo, che sarà pari a 4 anni come riportato nella convenzione "Agreement for International Ph.D. in Information and Communication Technologies". I 4 studenti del percorso internazionale UNIPA-INRS, previo superamento di un singolo esame finale di Dottorato, riceveranno il doppio titolo di Dottore di Ricerca in *Information and Communication Technologies* (UNIPA) e in *Sciences de l'énergie et des matériaux* (INRS). I dottorandi di questo percorso internazionale svolgeranno la propria attività per 16 mesi presso UNIPA e per 32 mesi presso l'INRS, in accordo con la disciplina legale sia italiana che del Quebec.

L'altro posto con borsa ed il posto senza borsa non fanno parte di tale accordo di co-tutela con INRS, ma dovranno comunque essere inseriti in un percorso internazionale a doppio titolo. L'accordo con l'Heriot-Watt University (HWU) prevede che il periodo di permanenza in UNIPA e HWU sarà circa equivalente e potrà essere effettuato a periodi alterni, in base a quanto pianificato dai due supervisori. L'accordo con l'Università libera di Bruxelles (ULB) prevede invece che il periodo di permanenza in UNIPA e ULB sia concordato in base alle esigenze dei due supervisori,

con una permanenza minima di un anno in ciascuna sede. Altri accordi per co-tutela di tesi potranno essere finalizzati in base ai temi di ricerca proposti dagli studenti di dottorato.

In tutti i casi, la tesi di Dottorato sarà scritta in Inglese e discussa in una delle lingue delle istituzioni partner. Lo studente dovrà anche preparare un sommario della tesi nelle lingue delle due istituzioni coinvolte nel percorso a doppio titolo. La tesi di Dottorato sarà discussa in una sola delle due istituzioni, in presenza di una singola commissione.

PROCEDURA SELETTIVA

Le prove selettive si svolgeranno nel periodo 25 settembre 2017 – 10 ottobre 2017.
Le date esatte delle prove saranno pubblicate entro il 31 luglio 2017 sul sito dottorati di ricerca:
http://portale.unipa.it/amministrazione/area2/set15/uob18/
Eventuali variazioni saranno pubblicate al medesimo link e avranno valore di notifica.

1. La prova scritta per tutti i candidati sarà svolta in lingua inglese – Art.10 comma f) del regolamento

Candidati italiani o stranieri su posti ordinari *Prova via Skype non prevista*		
Modalità di Selezione (spuntare le caselle)	**Data e ora della prova**	**Luogo della prova**
[X] Prova Scritta	Data da definire	Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici (DEIM) Edificio 9, Secondo piano - Parco d'Orleans Università degli Studi di PALERMO
[X] Prova Orale	Data da definire	Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici (DEIM) Edificio 9, Secondo piano - Parco d'Orleans Università degli Studi di PALERMO

Candidati laureati all'estero su posti riservati o su posti in soprannumero *Prova via Skype opzionale*		
Modalità di Selezione (spuntare le caselle)	**Data e ora della prova**	**Luogo della prova**
[X] Prova Orale	Data da definire	Dipartimento di Energia, Ingegneria dell'Informazione e Modelli Matematici (DEIM) Edificio 9, Secondo piano - Parco d'Orleans Università degli Studi di PALERMO
Contatto Skype (obbligatorio)	phd-ict-unipa	