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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2024

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Department Name: Department of Information, Electronics and Bioengineering (DEIB)

Research topic: Internet of Bio-Nano Things (IoBNT)

MSCA-PF Research Area Panels:

- ECO_Economic Sciences
- X ENG_Information Science and Engineering
- ENV_Environmental and Geosciences
- LIF_Life Sciences
- MAT_Mathematics
- PHY_Physics
- SOC_Social Sciences and Humanities
- CHE_Chemistry

Brief description of the Department and Research Group (including URL if applicable):

DEIB is one of the largest European ICT departments, with nearly 1000 members, researchers, collaborators, PhD students, technical and administrative staff. The six department sections cluster consolidated competences in telecommunications, systems and control, computer science and engineering, electronics, bioengineering and electrical engineering. Research Transmission Group at DEIB is devoted to the main aspects of the information transmission systems. Its research focuses on communication and information theory. The Transmission Group, constituted by 8 professors and several post-doc researchers and PhD students, has spaces dedicated to PhD students within DEIB facilities, equipped with desktops and state-of-art software for analysis and system simulations. The supervisor currently coordinates eight PhD students in technologies for mobile communications.

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TITLE of the project: Networking nanoscale sensors and transceivers for IoBNT

Brief project description:

The Internet of Bio-Nano Things (IoBNT) represents a revolutionary communication framework that involves diverse networks consisting of both biological components and artificial micro/nano-scale devices known as Bio-Nano Things (BNTs). These BNTs are integrated with traditional communication networks to support novel applications in the fields of biomedicine and the environment through bio transducer interfaces. IoBNT expands on the Internet of Things (IoT) concept by incorporating nanoscale devices, allowing for communication and data sharing between biological and nanoscale entities. Molecular communication, a key aspect of IoBNT, facilitates the transfer of information through the exchange of molecules, driving progress in the nanonetwork sector.

Recently, there has been a significant change in healthcare monitoring, driven by the development of tiny implantable devices at the nanoscale that can both detect and send critical data. These devices have great potential to transform healthcare by allowing ongoing, immediate monitoring of bodily functions inside humans. Currently, there is a lack of a holistic system or tool to design and network around the human body (body area network and intra-body network). With this project, we envision developing a tool to interconnect different BNTs within and around the human body.

There are various modalities for sensing within the body, each providing distinct capabilities and uses. These methods encompass electrochemical, optical, biomechanical, biological sensing, and others. Within the context of the BNT transceivers, communication can be achieved through intrabody communication techniques such as galvanic coupling as well as through industrially established terahertz communication. Terahertz communication, which utilizes nanoscale antennas, presents numerous benefits for communicating within the body, such as high data transmission rates, low energy consumption, and minimal disruption to biological tissues. Our project seeks to create an all-encompassing modular system for continuous health monitoring and diagnostics by combining terahertz communication with a range of sensing methods. This integration aims to revolutionize personalized and proactive healthcare. Our initial steps involve theoretical models, simulation verification, and moving towards manufacturing and thorough testing.

The main objectives of our project are as follows:

1. Theoretical Assessment of Performance: Evaluating the theoretical performance of nanodevices with respect to their sensing and communication abilities.
2. Analysis of Network Performance and Optimization: Assessing how multiple nanodevices function together within a biological setting in terms of network performance and the interaction with biology, such as toxicity. Further optimization of the network through the employment of signal modulation techniques and other signal processing methods.
3. Simulator Development: Developing simulation frameworks for nanosensors with a plug-and-play architecture to support different sensing methods currently in use.
4. Simulation of In-body Networks: Creating a network simulation established by these nanodevices within a biological system to verify theoretical predictions and evaluate practical performance.

The suggested study on Nanoscale Biosensors and Transceivers for IoBNT is an innovative initiative aimed at achieving the goal of continuous health monitoring using nanotechnology. By leveraging recent progress in nanoscale communication and sensing tools, the project aims to establish the groundwork for a future in which healthcare is tailored, accurate, and anticipatory. Through thorough theoretical examination, simulation, and experimental confirmation, our aim is to drive the IoBNT field towards remarkable progress in healthcare provision and surveillance.