Georgia Tech

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Distinguished Lecture Series

Intercellular Communication: Can It Be Mediated by Electromagnetics?

FEATURING

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Friday, November 18th, 2022
11:00 a.m. - Noon EDT
Location: TSRB 118 Auditorium
PIZZA & BEVERAGES FOLLOWING

Abstract: A group of cells within an organ or a community of unicellular organisms cannot function without being able to communicate. Their proper function or even their survival relies on their ability to interact with each other and the outside environment. The commonly accepted communication mechanism among biological cells is known as quorum sensing (QS), a process of communication by which cells release chemical molecules (auto-inducers) to their surroundings that can propagate through the process of diffusion and be received by the adjacent cells. This communication scheme, however, is slow as it relies on the diffusion of molecules in the surrounding medium. Additionally, it is estimated that individual cells require relatively large amount of energy (~mJ/mL)) for such processes. Alternatively if cells were equipped with radio transceivers, communication links could be established by electromagnetics waves. To examine such hypothesis we focused our research on certain bacteria biofilms and postulated a mechanism for the operation of such biological radios. The operating principle for the embedded radios within cellular structures and biofilms is proposed to be based on mechanical antennas. Certain bacterial cells within their biofilms are equipped with elastic helical fibers called amyloid fibrils with a built-in permanent electric dipoles. Through metabolic activities and release of accumulated stress the cells mechanical motions is transferred to oscillation motion of charged amyloid fibrils. Accelerated charges of these fibrils radiate electromagnetic waves at frequencies that depend on different vibrational modes of the fibrils which may include one or more of the followings: 1) cantilever beam mode, 2) longitudinal spring vibrational mode, and 3) transverse spring modes. A theoretical multiphysics model based on coupled system of electrical and mechanical structures is developed to explain the operation of EM-based communication. Using communication channel theory, it is shown that EM signaling can provide much higher data rate (5 to 7 orders of magnitude) and over much longer ranges compared to QS. Guided by the theoretical model, novel measurement instrumentations are developed to explore the presence of electromagnetic radiation from growing bacterial biofilms in a controlled environment. These sensitive measurement systems together with appropriate signal processing tools are capable of detecting extremely weak signals in the presence of noise. In particular a wideband near-zone radiative system is designed to operate in 1-50 GHz range in a discovery mode. Then a near-filed spiral antenna system and a regenerative RF sensing system are designed and fabricated for more accurate measurements. We, for the first time, were able to identify EM radiation from Staphylococcus aureus biofilms in the 3-4 GHz frequency range consistently and repeatedly. Experiments were carried out to determine long-term and short-term cycles of the emitted signals over the course of 70-day experiments. Experimental techniques and results will be presented in this talk.

"Professor Sarabandi is a member of the National Academy of Engineering."

Biography: *Kamal Sarabandi* is the Fawwaz T. Ulaby Distinguished University Professor of EECS and the Rufus S. Teesdale Endowed Professor of Engineering at The University of Michigan. His research areas of interest include microwave and millimeter-wave radar remote sensing, Meta-materials, electromagnetic wave propagation, antenna miniaturization, and bio-electromagnetics. Professor Sarabandi has supervised 64 Ph.D. and numerous Masters students and postdoctoral fellows. He has published a text book, many book chapters, more than 325 papers in refereed journals, and more than 770 conference papers. His contributions to the field of electromagnetics have been recognized by many awards including Humboldt Research Award, the IEEE GRSS Distinguished Achievement Award, the IEEE Judith A. Resnik medal, the IEEE GRSS Education Award, NASA Group Achievement Award, and many other awards from the University of Michigan. He is a Fellow of the IEEE, a Fellow of the American Association for the Advancement of Science (AAAS), and a Fellow of the National Academy of Inventors. Professor Sarabandi is a member of the National Academy of Engineering.

Hosts: Nima Ghalichechian & Farrokh Ayazi