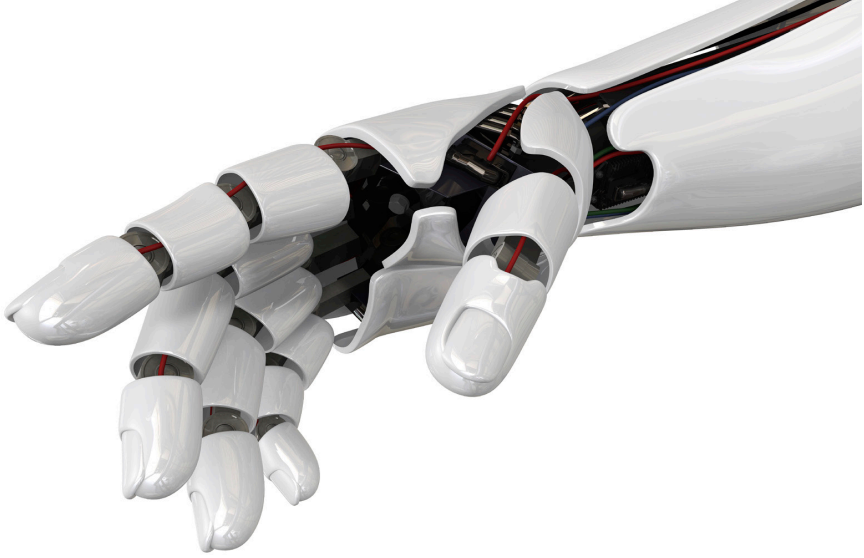
ECE SEMINAR

Department of Electrical and Computer Engineering



December 16, 2016
10:00am-11:00am
Dean's Conference Room
E421 Engineering Bldg 2

Dr. Levent Gürel

ABAKUS Computing Technologies

Solution of Extremely Large Forward and Inverse Problems in Computational Electromagnetics: BIG DATA Aspects

As we solve some of the largest problems in the interdisciplinary domain of computational electromagnetics, we have to deal with various aspects of big-data issues routinely. Most recently, we have achieved the solutions of larger than 1,500,000,000x1,500,000,000 (1.5 billion!) dense matrix equations! This achievement is an outcome of a multidisciplinary effort involving physical understanding of electromagnetics problems, novel parallelization strategies (computer science), constructing parallel clusters (computer architecture), advanced mathematical methods for integral equations, fast solvers, iterative methods, preconditioners, linear algebra, and big data. Solving such large problems on a regular basis requires the generation, representation, storage, processing, analysis, transfer and communication, visualization and interpretation of extremely large data sets in the order of multiple terabytes. Accurate formulations of real-life electromagnetics problems with integral equations necessitate the solution of extremely large dense matrix equations. Solutions of such tremendously challenging problems cannot be achieved easily, even when using the most powerful computers with state-of-the-art petascale computing capabilities. Instead, we have been solving some of the world's largest integral-equation problems in computational electromagnetics by employing fast algorithms implemented on parallel computers. To achieve optimal management of multiple large data sets, we design and implement the handling of data in various levels of cache, memory, and disk, leading to meticulously designed out-of-core (OoC) schemes. That way, we enable the solution of unprecedentedly large problems with limited amounts of DRAM. In order to avoid decelerating the solution, we optimize communications among CPU cores, among processors, among nodes, from CPU to disk (and back), and in the case of heterogeneous architectures, we carefully control the data traffic to/from GPUs. Furthermore, we employ MPI and OpenMP simultaneously in a parallelization strategy designed to reduce data duplications among processes so that vast numbers of cores can be efficiently utilized without requiring extra memory. I will present fast and accurate solutions of large-scale electromagnetic forward and inverse problems involving three-dimensional geometries that are larger than 1000 wavelengths using the multilevel fast multipole algorithm (MLFMA) and parallel MLFMA. Solving the world's largest computational electromagnetics problems has important implications in terms of obtaining the solutions of future grand-challenge problems in imaging, (subsurface), optics, nanotechnology, bio-electromagnetics, metamaterials, remote sensing, as well as plethora of other disciplines of science, e.g., acoustics, elastics, quantum mechanics, astrophysics, molecular dynamics, electro-statics, fluid dynamics, thermodynamics. For more information: http://captains.of.computing.technology/.

Prof. Levent Gürel (Fellow of IEEE, ACES, and EMA) received the M.S. and Ph.D. degrees from the University of Illinois at Urbana-Champaign (UIUC) in 1988 and 1991, respectively, in electrical and computer engineering. He worked at the IBM Thomas J. Watson Research Center, Yorktown Heights, New York, in 1991-94. During his 20 years with Bilkent University, he served as the Founding Director of the Computational Electromagnetics Research Center (BiLCEM) and a professor of electrical engineering. He is also an Adjunct Professor at UIUC. Prof. Gürel is the Founder and CEO of ABAKUS Computing Technologies, a company that is geared towards advancing the use of cutting-edge computing technologies for solving difficult scientific problems with important real-life applications and societal benefits. He is conferred the UIUC ECE Distinguished Alumni Award in 2013 and the IEEE Harrington-Mittra Award in Computational Electromagnetics in 2015. He is an IEEE Distinguished Lecturer. He was invited to address the 2011 and 2017 ACES Conferences as a Plenary Speaker and a TEDx Conference in 2014. Among other recognitions of Prof. Gürel's accomplishments, the two prestigious awards from the Turkish Academy of Sciences (TUBA) in 2002 and the Scientific and Technological Research Council of Turkey (TUBITAK) in 2003 are the most notable. Since 2003, Prof. Gürel has been serving as an associate editor for Radio Science, IEEE Transactions on Antennas and Propagation, IEEE Antennas and Wireless Propagation Letters, IET Microwaves, Antennas & Propagation, JEMWA, PIER, ACES Journal, and ACES Express.

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