15 January 2015

Research Experience

From 2010 until recently, I had been affiliated with the Computational Electromagnetics Research Center of Bilkent University, Ankara. I started working in the research center when I was a second-year undergraduate student. I conducted several state and industry-funded projects with Prof. Levent Gürel, who was the director of the center, currently a professor emeritus. The list of the projects and their brief descriptions are given below.

Industry-Funded Projects

Radar-Cross-Section (RCS) Calculations of Chaff Clouds: We employed the parallel multilevel fast multipole algorithm (MLFMA) in order to solve scattering problems involving chaff clouds. Various dipole lengths are investigated in order to inquiry the most appropriate chaff cloud configuration for hiding a target at certain frequencies. Several types of cloud shapes and dipole-position randomizations are configured in order to model the clouds at different time instants. Contractor: ASELSAN

Jet Trainer/Fighter RCS Analysis: RCS calculations of a fifth-generation fighter jet that Turkey aims to develop to replace aging F-16 fighter jets. Monostatic RCS results of several potential models are provided at certain frequencies and illumination angles. Parallel MLFMA and physical optics solvers are used for providing full-wave and approximate solutions, respectively. Contractor: TAI-SSM

Computational Methods for Antennas Mounted on Platforms: Several computational methods are developed in order to calculate interactions between antennas and platforms. Various types of spiral and blade antennas and platforms are analyzed. Integral equations and hybrid physical optics & integral equations are the two main formulation schemes for solving the electromagnetics problems. Source reconstruction technique and equivalence principle algorithms are two types of auxiliary methods for calculating the necessary electromagnetic interactions. The project also involves geometrical and mathematical modeling of antennas and electromagnetic sources. Contractor: ASELSAN-SSM

State-Funded Projects

Breast Cancer Detection via Inverse scattering: The project aims to reconstruct an object shape with a Newton minimization approach. The framework is fully numerical and we use the MLFMA for solving forward scattering problems. Contractor: TÜBİTAK

Parallel Electromagnetic Equivalence Principle Algorithm: We use equivalence principle in order to model complicated structures using equivalent currents on basic surfaces. We use multipole methods for fast calculation of the incident field at a point originated by sources. Contractor: TÜBİTAK

ASELSAN*: Military Electronic Industries Inc.*
SSM*: Undersecretariat for Defense Industries*
TAI*: Turkish Aircraft Industries Inc.*
TÜBİTAK*: Scientific and Technological Research Council of Turkey*

My undergraduate and graduate studies have been funded by the above projects. Besides those, I have been concentrated on solutions of large-scale electromagnetics problems using MLFMA. In order to solve large-scale problems, I parallelized pre-processing data-structures of MLFMA in order to eliminate memory bottlenecks. I also implemented an out-of-core method for parallel MLFMA, which utilizes the disk space on the computing platform for storing large data structures. In addition, I recently applied hybrid MPI+OpenMP parallelization on MLFMA to retain its parallelization efficiency with a high number of processes/threads. In 2009, the largest problem that could be solved involves 540 million unknowns, but with the applied techniques, now we can solve 1.3 billion unknowns with the same computer cluster. Being able to cope with large-scale problems is very crucial for obtaining full-wave, i.e., accurate, solutions of real-life electromagnetics problems.

Starting from sophomore year, have been using an eight-node and a 16-node dedicated parallel computer clusters located in Bilkent. I also used a 64-node cluster located in Cyprus. For the last 16 months, I have been using a dedicated 16-node cluster located in Swindon, UK, provided by the Intel Corporation. Intel also provided us a server equipped with brand-new Xeon Phi coprocessors for trial of their new product for potential applications.

I was a part of the organization team in the CEM'11 and CEM'13 computational electromagnetics worksops, held in İzmir, Turkey. The conferences traditionally have strong technical and social programs. As an assistant at the conferences, I could find the chance to meet meritorious people of the computational electromagnetics society. We have already started working on CEM'15 which will be held in summer 2015. I was also a volunteer at the 2014 IEEE AP-S Symposium and North American URSI Meeting, held in Memphis, TN, USA in summer 2014.

As of today, I'm working on my master's thesis which involves computational and theoretical contributions for solving large-scale electromagnetics problems. The content of the thesis is based on the research that I had conducted during my four-year effort in BiLCEM. Notably, the real-life projects that I am involved in constitute a great portion of my contributions. One application is the hybrid physical-optics and integral-equation solutions. The technique combines the rapidity of physical optics and the accuracy of integral equations, where MLFMA is used for fast calculation of the interactions among domains. Recent commercial implementations of the hybrid technique show how useful the technique is, and its potential for employment in real-life applications.

As we (Prof. Gürel and I) are preparing several papers for the IEEE AP-S, ACES, URSI, PIERS, and CEM'15 conferences, I have made my plans in order to continue working with him upon starting a new degree. My surrogate advisor is Prof. Ömer İlday of the Ultrafast Optics and Lazers Laboratory upon my graduation because Prof. Gürel retired from the university recently.

Conference Papers

M. Hidayetoğlu and L. Gürel, "Full-wave and approximate solutions of large electromagnetic scattering problems," *2015 IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting*, Vancouver, Canada, Jul. 2015, in print.

M. Hidayetoğlu and L. Gürel, "Acelerating hybrid integral-equation and physical-optics solutions with MLFMA," *URSI Atlantic Radio Science Conference 2015 (AT-RASC 2015)*, Gran Canaria, Spain, May 2015, in print.

M. Hidayetoğlu and L. Gürel, "Parallel implementation of the out-of-core MLFMA solver," *The 31st Int. Review of Progress in Applied Computational Electromagnetics (ACES 2015)*, Williamsburg, VA, USA, Mar. 2015, in print.

M. Hidayetoğlu and L. Gürel, "MLFMA memory reduction techniques for solving large-scale problems," *2014 IEEE International Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting*, Memphis, TN, USA, Jul. 2014.

M. Hidayetoğlu, B. Karaosmanoğlu, and L. Gürel, "Reducing MLFMA memory with out-of-core implementation and data-structure parallelization," *Computational Electromagnetics Workshop (CEM'13)*, İzmir, Turkey, Aug. 2013.

Others

M. Hidayetoğlu and L. Gürel, "BiLCEM researchers making aircraft stealthier," *Bilkent News*, Mar. 2014.

M. Hidayetoğlu and L. Gürel, "Hybrid PO-MoM solutions of electromagnetic scattering problems involving PEC geometries," *Bilkent University IEEE Graduate Research Conference (GRC'14)*, Ankara, Turkey, Mar. 2014.

M. Hidayetoğlu and L. Gürel, "Memory reduction by parallelizing data structures of MLFMA," *Bilkent University IEEE Graduate Research Conference (GRC'13)*, Ankara, Turkey, Mar. 2013.

M. Hidayetoğlu, B. Karaosmanoğlu, and L. Gürel, "MLFMA solutions of electromagnetic scattering from chaff clouds," *Bilkent University IEEE Graduate Research Conference (GRC'12)*, Ankara, Turkey, Mar. 2012.

In Progress

M. Hidayetoğlu and L. Gürel, "MLFMA employment for hybrid physical-optics and integral-equation solutions," *Antennas and Wireless Propag. Lett.*, 2015.

M. Hidayetoğlu and L. Gürel, "Out-of-core implementation for the parallel multilevel fast multipole algorithm," *Antennas and Wireless Propag. Lett.*, 2015.

M. Hidayetoğlu, "Large-scale solutions of electromagnetics problems using the multilevel fast multipole algorithm," M.S. thesis, Dept. Elect. Electron. Eng., Bilkent Univ. Ankara, Turkey, Mar. 2015.