Emmanuel Garza

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Education

PhD in Applied and Computational Mathematics **Sep 2013 – Jan 2020**

California Institute of Technology, Pasadena CA

Dissertation: "Boundary Integral Equation Methods for Simulation and Design of Photonic Devices"
Committee: Oscar P. Bruno (Advisor), Andrei Faraon, Constantine Sideris and Houman Owhadi

Bachelor of Science in Engineering Physics **Aug 2008 – Jun 2013**

Tecnológico de Monterrey, Mexico

Bachelor Dissertation: "Propagation of Spirally Polarized Beams Through Anisotropic Media"
Advisor: Julio C. Gutiérrez-Vega

Research Interests

- High-order boundary integral equations (BIE) for electromagnetic scattering using distributed computing
- Novel algorithms for fast design of photonic devices using adjoint methods and machine learning techniques
- Facilitate the widespread use of BIE for large-scale electromagnetic simulation and optimization of devices through the implementation of efficient, fast and high-order accurate open-source BIE software

Research and Work Experience

Postdoctoral Scholar – Research Associate **Jul 2020 – Present**

University of Southern California, Los Angeles CA

- Designing a C++ library for electromagnetic scattering
- Developing algorithms for the design and optimization of nanophotonic devices

Data Science Fellow **Jan 2020 – Mar 2020**

Insight Data Science, Los Angeles CA

- Scraped and cleaned the data for over 73,000 esport matches, updated daily using cron jobs
- Built and deployed a web app using Python/Flask, HTML and AWS, which predicts whether a specific roster change on a team improves the probability of winning, and quantifies it using random forest
- Applied clustering and nearest neighbor techniques to find potential replacements for a team

Research Assistant **Sep 2013 – Jan 2020**

California Institute of Technology, Pasadena CA

- Developed a three-dimensional Nyström boundary integral equation method for electromagnetic scattering
  - Implemented and deployed several Fortran libraries, which are used by researchers at Caltech
  - Coded a parallel implementation of the method, using both MPI and OpenMP, with parallel efficiencies in between 80% and 95% for a cluster with 30 nodes and 24 cores per node (720 computing cores)
- Designed and implemented fast gradient descent optimization methods for designing optical devices such as optical fibers and metalenses, with speedups of up to 400 times compared to more conventional approaches
- Implemented a novel algorithm based on singular value decomposition to find guided modes of waveguides

Summer Undergraduate Research Fellow **Summers of 2011 and 2012**

California Institute of Technology, Pasadena CA

- Implemented MATLAB code to model fluid dynamic problems using Fourier spectral methods
- Developed Fortran software to model photonic crystals using finite-difference and Fourier methods

Teaching Experience

Teaching Assistant **Sep 2014 – Dec 2019**

California Institute of Technology, Pasadena CA

- Supported students of graduate-level courses in applied mathematics (ACM 101ab and ACM 106a)
- Led office hours and recitations for class topics pertaining scientific computing, numerical methods, linear algebra, computational physics, asymptotic and perturbation methods, among other topics

Mentor for Summer Undergraduate Research Fellows **Summers of 2014 and 2015**

California Institute of Technology, Pasadena CA

- Mentored undergraduate research fellows on a one-on-one basis for their summer research projects
- Provided technical advise on a daily basis to ensure the students achieve their project goals

Teaching Assistant **Aug 2010 – Jul 2013**

Tecnológico de Monterrey, Mexico

- Taught the lab section of introductory physics courses (Newtonian mechanics, waves, and electromagnetics)
- Trained the students to use laboratory equipment, and supervised their coursework

Honors and Awards

Saul Kaplun Fellowship **Sep 2014**

California Institute of Technology, Pasadena CA

- Funds graduate research in applied mathematics for the 2014-2015 academic year

Mención Honorífica de Excelencia **Jun 2013**

Tecnológico de Monterrey, Mexico

- Graduated first among the Engineering Physics class of 2013, with a cumulative GPA of 98/100

Beca de Excelencia **Jun 2008**

Tecnológico de Monterrey, Mexico

- Scholarship that cover 90% of college tuition
- Awarded for graduating first among the International Baccalaureate students at CEGS high-school

Technical Skills

Programming: Fortran, Python (NumPy, Matplotlib, pandas, scikit-learn, Flask), MATLAB, C/C++, SQL, Mathematica, Makefiles, parallel programming with MPI and OpenMP, SLURM, Linux OS, Git, LaTeX, scientific visualization with VisIt (LLNL), bash scripts, experience with libraries like MKL, LAPACK, FFTW

Knowledge: Numerical analysis, numerical optimization, linear algebra, Fourier and spectral methods, numerical methods for PDEs (boundary integral equations, finite-difference time/frequency-domains), regression and classification methods (linear/logistic, decision trees, random forests, boosting, support vector machines, k-nearest neighbors), clustering (k-means, hierarchical), principal component analysis

Languages: English (bilingual proficiency) and Spanish (native)

Publications – ORCID 0000-0003-1687-8216

[1] Constantine Sideris, **Emmanuel Garza**, Oscar P. Bruno. "Ultrafast Simulation and Optimization of Nanophotonic Devices With Integral Equation Methods". ACS Photonics 6 (12), 3233-3240 (2019). doi.org/10.1021/acsphotonics.9b01137

[2] **Emmanuel Garza**, Servando Lopez-Aguayo, Julio C. Gutiérrez-Vega. "Soliton Dynamics in Finite Non-Local Media With Cylindrical Symmetry". Physical Review A 99 (3) 033804 (2019). doi.org/10.1103/PhysRevA.99.033804 - arxiv.org/abs/1808.08889

[3] Oscar P. Bruno, **Emmanuel Garza**. "A Chebyshev-Based Rectangular-Polar Integral Solver for Scattering by General Geometries Described by Non-Overlapping Patches". arXiv (2018). arxiv.org/abs/1807.01813

[4] Oscar P. Bruno, **Emmanuel Garza**, Carlos Pérez-Arancibia. "Windowed Green Function Method for Nonuniform Open-Waveguide Problems". IEEE Transactions on Antennas and Propagation 65 (9) 4684-4692 (2017). doi.org/10.1109/TAP.2017.2728118 - arxiv.org/abs/1610.04939

Conference Presentations and Posters

[1] **Emmanuel Garza** and Oscar P. Bruno. "Novel Integral Equation Scattering Solver, With Applications to Open-Waveguide Problems via the Windowed Green Function Method". ICOSAHOM, London (2018).

[2] Constantine Sideris, **Emmanuel Garza**, Oscar P. Bruno. "Silicon Photonic Device Optimization With Integral Equation Methods". DARPA/DSO EXTREME PI Meeting. Pasadena, CA (2018).

[3] Oscar P. Bruno, Agustin Fernandez-Lado, **Emmanuel Garza**, Edwin Jimenez. "Fast and Accurate 3D Numerical Methods for Optimized Multi-Functional Optical Systems". DARPA/DSO EXTREME PI Meeting. Pasadena, CA (2018).

[4] **Emmanuel Garza**, Edwin Jimenez, Oscar P. Bruno. "The Windowed Green Function Method for Maxwell's Equations". Vannevar Bush Faculty Fellowship Meeting. Dayton, Ohio (2017).

[5] **Emmanuel Garza** and Oscar P. Bruno. "Windowed Green Function Method and Maxwell Eigenfunctions for Open-Waveguide Problems". WONAPDE, Concepción, Chile (2016).

[6] **Emmanuel Garza** and Julio C. Gutiérrez-Vega. "Propagación de Haces Espirales Vectoriales a Través de Materiales Anisotrópicos" Conexión Tec, Tecnológico de Monterrey, Mexico (2013).