Electromagnetic Education and Antenna Technology: Past, Present and Future

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ABSTRACT

The field of Electromagnetics (EM) includes theoretical and applied concepts, both of which are described by a set of basic analytical laws, widely acclaimed as Maxwell's equations. These laws were formulated primarily through experiments conducted during the nineteenth century by many scientists, and they then were combined into a consistent set of vector equations. These laws, both in differential and integral form, withstood the test of time for over two centuries, and they have been the foundation of electrical engineering and physics curricula. They have successfully been applied to numerous problems, and the results have compared favorably with experimental and simulated data. While there have been no basic changes in the initial structure of these basic laws, there has been an impressive surge in their application, especially during the last 50 or so years. Because of the dramatic increase in the geometrical complexity of the new problems, whose geometries were not of canonical shapes and could not be described by basic orthogonal coordinate systems, the solutions of most of them could not be derived in closed-form using analytical expressions. This necessitated the development of numerical methods to solve these complicated problems, whose solutions would otherwise have remained dormant. The history of EM and its integration to Electrical Engineering curricula will be briefly reviewed.

The genesis of the application of numerical methods to electromagnetics may have started in the 1960s, aided and supported by the advancement of computational resources. These computational methods and associated software have been integrated in current curricula of Electrical Engineering, both at the undergraduate and graduate levels. While users are currently highly dependent on these computer codes, we should not lose focus on the interpretation and physical realization of the data simulated using these full-wave solvers. Therefore, the analytical methods are, and will continue to be, the foundation of electromagnetics and provide understanding and physical interpretation of electromagnetic phenomena and interactions.

Antenna technology has undergone a dramatic evolution from the days of Hertz, with his spark-gap with end-loaded dipole, to today's high performance Active Electronically Scanned Arrays (AESA) and multiband antennas for smart phones and mobile devices. The antenna technology reached even greater heights with the introduction and advancements of integrated circuits, solid state technology, unique and creative radiator designs, and signal processing algorithms. Recently electromagnetic band-gap structures, and the integration of Artificial Magnetics Conductor (AMCs), have begun to play a pivotal role. Although numerical and computational methods, and associated full-wave simulators, have also contributed to this advancement, basic concepts and fundamental principles in the physical realization, interpretation and verification of designs of simulated should be emphasized. The timelines over which antenna technology leaped forward are identified, and the various antenna configurations developed during those periods are highlighted. Future trends in antenna technology are identified and suggested.