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Brief Summary for Grant Proposal to Motorola Solutions Foundation

Recent developments in additive manufacturing have unlocked the potential for undergraduate student researchers to develop radio-frequency (RF) antenna designs for radar, telecommunications, and physics research. Using a combination of open-source software, CAD tools, and 3D printing, RF antennas for diverse applications can be produced by students at low cost. There is a strong educational potential for for first-generation and diverse undergraduate student populations in Southern California, given the value of engineering skill applicable to burgeoning economic sectors in this region. Whittier College has a long history of boosting diversity and first-generation participation in undergraduate research. In the area of RF design, Whittier College has collaborated with the Office of Naval Research (https://www.onr.navy.mil). Whittier College has joined the participating institutions in The IceCube Collaboration (https://icecube.wisc.edu). In our Integrated Computer Science and 3-2 Engineering Programs, we have a diverse set of students ready to participate in hands-on learning experiences designed to prepare them for roles in the defense sector, aerospace, and telecommunications.

Our program will finance research fellowships made available to first-generation and diverse STEM students. We will begin with Python coding boot-camps that introduce students to open-source computational electromagnetism (CEM). Open-source software is free, and CEM is used to predict the performance of RF and microwave systems. Our students have already won scholarships for this research through Whittier College, with funding provided by The Fletcher-Jones Foundation and the Office of Naval Research. Experienced students will be recruited to help guide new participants in a small group setting, building a culture of progress through peer-learning. Participants will learn how to utilize efficiently our in-house high-performance computing resources, which have already been acquired with start-up funding. A key milestone for the students will be when they understand the different purposes of individual software projects, and working as a small team to run high-performance studies in a centralized system with many CPU cores.

As the students' coding skills progress, we will begin exploring standard RF antenna designs. Once the students master simple antenna shapes, with well-understood properties, the students will begin to incorporate machine learning techniques into the design phase. Machine learning is used to optimize designs for application-specific goals. The applications are motivated by our ongoing partnerships with ONR and IceCube. A common machine-learning example is the genetic algorithm, in which the geometry of our designs are encoded into numerical genes that are then allowed to evolve through natural selection, according to specified performance criteria. Once the students master the process of initial design guess, evolution phase, assessment of design performance, and further evolution, the group will be able to reliably optimize designs. At the end of the coding phase, students will learn to translate optimized designs for 3D printing.

Using newly developed conductive 3D printing filament (https://www.multi3dllc.com), the students will print RF elements to form phased arrays in the [1-10] GHz bandwidth. Using standard microwave test equipment in our laboratories, we will verify the operation of our end products. We already have the test equipment, computational power, and students. If granted financial support for the 3D printing and research administration, we will produce educational outcomes and results useful for our students, and for organizations like Motorola, IceCube, and the Navy. Our research fellowships will conclude by facilitating the integration of our results into the course curriculum of Whittier College, so that future generations of students will benefit. Students will be given time and space within our engineering courses to share their results and experiences with the next generation of Whittier College undergraduates.