PROJECT SUMMARY

Overview:

Recent advances in deep learning have stimulated a tidal wave of research that has successfully applied deep learning to various problems in wireless communications and networking. The findings from these studies demonstrated the efficacy and value of deep learning when applied appropriately to complex problems in wireless technologies and applications. However, the wireless research community has yet to address one of the most critical challenges in this research area--viz., how to facilitate the acquisition of sufficient amounts of data to train and validate complex learning models. Researchers, as well as practitioners, universally agree that the efficacy of deep learning is heavily dependent on the availability of a sufficient amount of data. Some pundits go so far as to claim that the world's most valuable resource is no longer oil, but data. Whatever the case, it is evident that acquiring data for deep learning can be extremely expensive in terms of time and monetary expenses. The primary aim of the proposed research is to explore innovative approaches that enable wireless researchers and practitioners to acquire data more efficiently and utilize existing data more effectively, while at the same time incurring less man-hours and cost. Recognizing the significance of the aforementioned problems, a team of four investigators with complementary expertise from Auburn University (AU), Temple University (TU), and California State University, Sacramento (CSUS) propose a coherent research agenda that is composed of four thrusts described below.

Keywords: deep learning; wireless communications and networking; data augmentation; transfer learning; generative adversarial network (GAN); sample complexity.

Intellectual Merit:

The research agenda consists of four intertwined thrusts. Thrusts 1-3 are application-agnostic focused on studying fundamental concepts and techniques that facilitate the acquisition of sufficient amounts of wireless data, enable more effective utilization of existing data, or enable us to predict how much data is needed to meet a performance goal. Thrust 4 is application-specific focused on specific wireless applications where deep learning has been applied and demonstrated great potential. The primary motivation for including Thrust 4 is to integrate, validate, and evaluate the concepts and techniques that will be developed in Thrusts 1-3 through their application to canonical wireless applications. The four thrusts are: (i) Spectrum data synthesis and augmentation with a GAN approach; (ii) Development of novel transfer learning algorithms for wireless applications; (iii) Characterizing the relationship between dataset size and performance; (iv) Wireless spectrum applications for integration and validation, including spectrum database construction, RF spectrum anomaly detection, and transmitter classification.

Broader Impacts:

The proposed research is expected to have far-reaching broader impacts. First, by focusing on data-centric problems of high importance to the wireless research community, findings from this project are expected to facilitate breakthroughs in wireless research that require huge amounts of data to train complex deep learning models. Second, by integrating research and education, the proposed work will

provide excellent hands-on exercises, research, and educational opportunities for undergraduate and graduate students at the three collaborating universities. The PIs will jointly develop a new graduate course on Machine Learning for Wireless Spectrum Systems to be offered at the three campuses. In addition, the PIs will take advantage of the existing diversity-related outreach programs at their home institutions to recruit and involve students from underrepresented groups, while CSUS is designated as a Hispanic-Serving Institution (HSI), an Asian American and Native American Pacific Islander-Serving Institution (AANAPISI), as well as a Research in Undergraduate Institutions (RUI). Third, the PIs will make a coordinated effort to disseminate results through scholarly publications, a project website, online repositories (e.g., GitHub), offering a tutorial, and organizing a workshop and a journal special issue. In addition, the PIs will engage industry stakeholders on project-related issues with the aim to disseminate ideas and gain a good understanding of the relevant challenges faced by the industry when applying deep learning to wireless applications.