Enhancing Machine Learning Techniques for Occupancy Estimation and Socio-Physical Graph Reconstruction Using Reconfigurable Antennas

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The rapid proliferation of wireless devices offers new means to infer current conditions surrounding mobile users, their locations, and their actions. This is especially true for industrial, scientific, and medical (ISM) radio bands where communication protocols are often open and information about neighboring devices abounds. This work examines efficient occupancy estimation based on Wi-Fi metadata, with an emphasis on machine learning algorithms attuned to directional antennas with spatially discriminating patterns. Certain Wi-Fi interfaces can be switched into monitoring mode, an operating state where all local packets are observed and recorded. Using a network of such monitoring sensors, it is then possible to estimate the number of active devices within a specific area. The envisioned estimators take as input received signal strength indicators and media access control addresses. By using directional monitoring antennas, one can gain additional and/or more discriminating information about current conditions, thereby yielding enhanced occupancy estimates. This paper introduces novel algorithms and machine learning techniques that leverage this information to characterize the performance gains associated with RF-aware sensing devices. It is also used to perform a reconstruction of socio-physical networks obtained from the metadata. Experimental results based on a prototype implementation of this distributed monitoring system provide further supporting evidence for the proposed techniques. This now includes the use of reconfigurable antennas that can alter their radiation patterns to improve the discrimination of spatial sampling by these monitoring devices.