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Inversely Designed Chipless Radio Frequency Identification (RFID) Tags Using Deep Learning

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Abstract : Fully passive backscattering chipless RFID tags are an emerging wireless technology with low cost, higher reading distance, and fast automatic identification without human interference, unlike already available technologies like optical barcodes. The design optimization of chipless RFID tags is crucial as it requires replacing integrated chips found in conventional RFID tags with printed geometric designs. These designs enable data encoding and decoding through backscattered electromagnetic (EM) signatures. The applications of chipless RFID tags have been limited due to the constraints of data encoding capacity and the ability to design accurate yet efficient configurations. The traditional approach to accomplishing design parameters for a desired EM response involves iterative adjustment of design parameters and simulating until the desired EM spectrum is achieved. However, traditional numerical simulation methods encounter limitations in optimizing design parameters efficiently due to the speed and resource consumption. In this work, a deep learning neural network (DNN) is utilized to establish a correlation between the EM spectrum and the dimensional parameters of nested centric rings, specifically square and octagonal. The proposed bi-directional DNN has two simultaneously running neural networks, namely spectrum prediction and design parameters prediction. First, spectrum prediction DNN was trained to minimize mean square error (MSE). After the training process was completed, the spectrum prediction DNN was able to accurately predict the EM spectrum according to the input design parameters within a few seconds. Then, the trained spectrum prediction DNN was connected to the design parameters prediction DNN and trained two networks simultaneously. For the first time in chipless tag design, design parameters were predicted accurately after training bi-directional DNN for a desired EM spectrum. The model was evaluated using a randomly generated spectrum and the tag was manufactured using the predicted geometrical parameters. The manufactured tags were successfully tested in the laboratory. The amount of iterative computer simulations has been significantly decreased by this approach. Therefore, highly efficient but ultrafast bi-directional DNN models allow rapid and complicated chipless RFID tag designs.

Keywords : artificial intelligence, chipless RFID, deep learning, machine learning
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