TECHNION Israel Institute of Technology

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ACRC Architectures Circuits Research Center

Worlds Of Hardware 2024

Machine Learning Assisted Filter Design

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Introduction

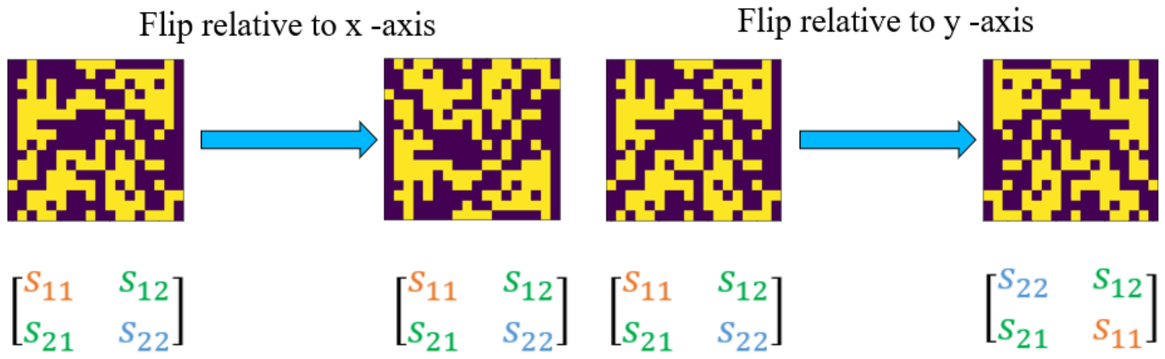
Machine learning techniques have transformed numerous scientific disciplines.
In this project, we implement a ML based filter design approach.
This approach opens up an entirely new design space for RF that doesn't exist in classic techniques, pixelated small EM structures.

Background

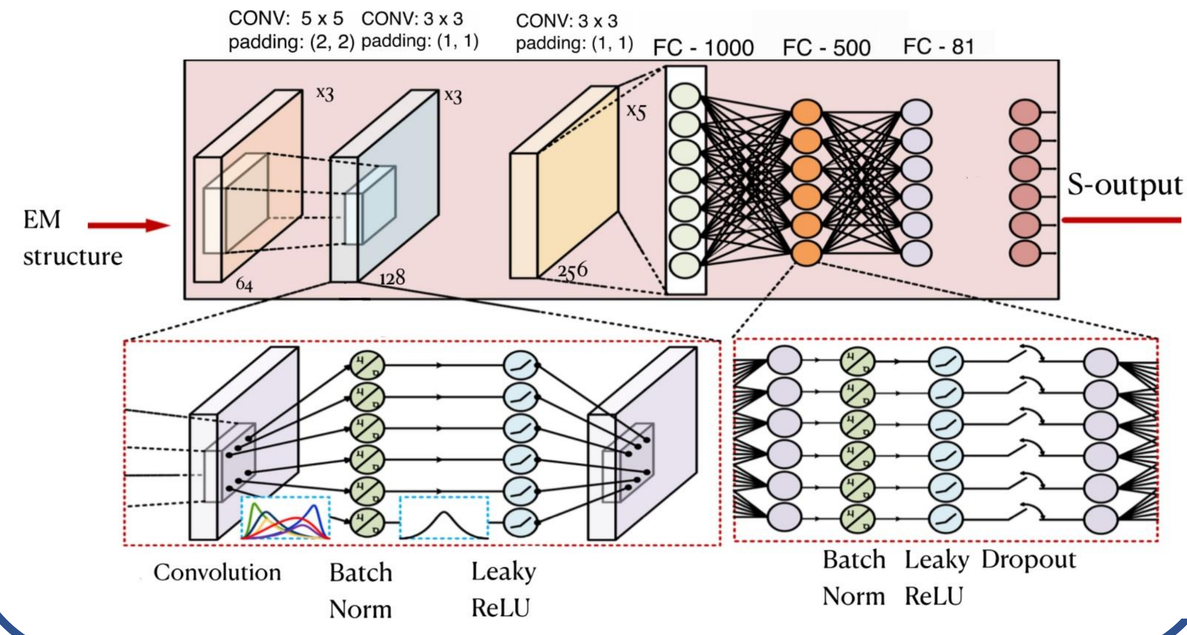
We apply the approach introduced in Deep Learning based Modeling and Inverse Design for Arbitrary Planar Antenna Structures at RF and Millimeter-Wave to filters.
Using a CNN we're able to evaluate a lot of designs faster than conventional simulations.
This lets us use a Genetic Algorithm to pick designs with desired scattering parameters.

Training Set Generation

We generate training samples, which are simulated in AWR with a python script, to form a significant Dataset. We use symmetry, as well as passivity, to triple our samples.

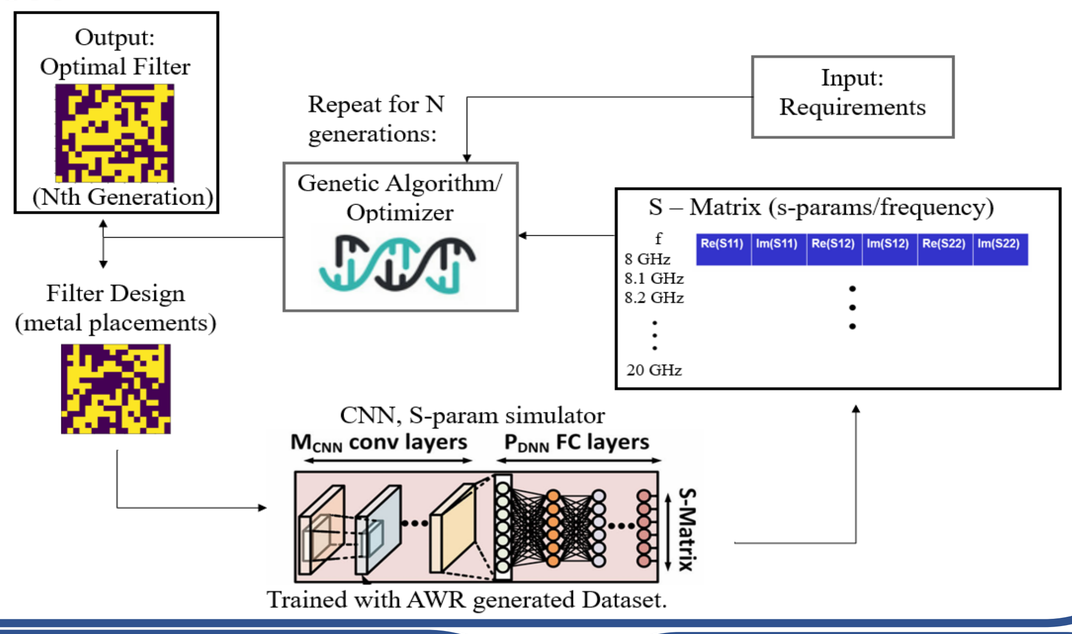


CNN Structure



Approach

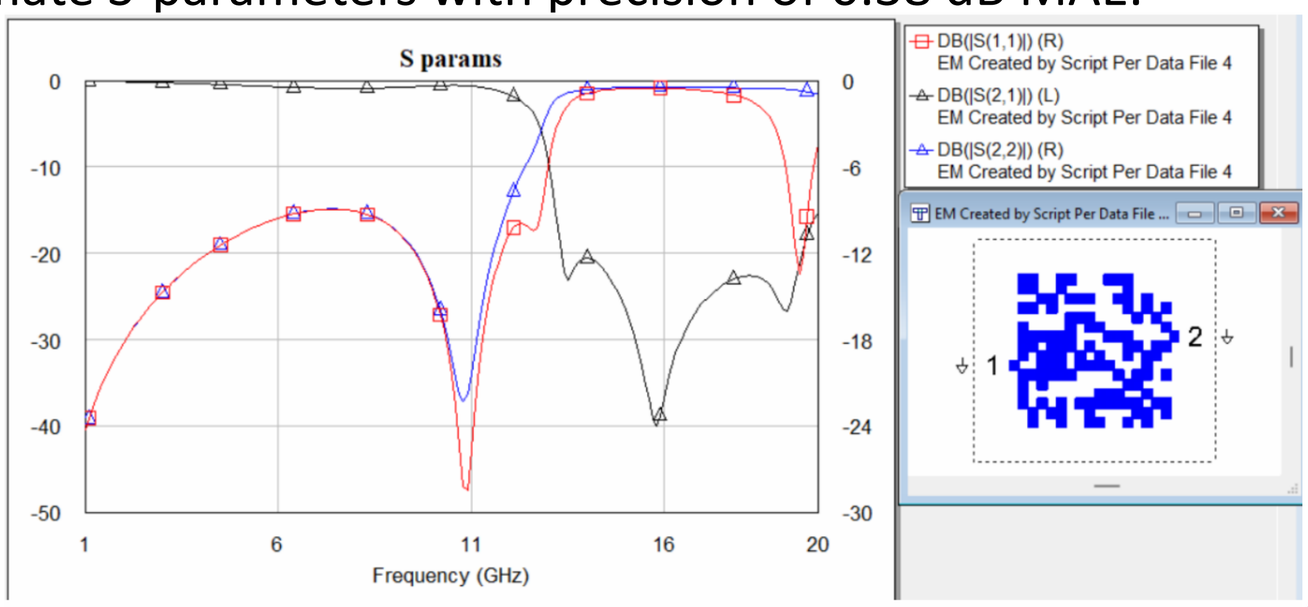
The Genetic Algorithm generates a population of random designs. Each member of the generation gets a precise EM prediction by the CNN structure that we trained on our created Dataset. We use a score function to evaluate each design's fitness. Then we create a new population with genetic operations to receive better performance in the next generation. The process is repeated for N generations. In the end we get the optimized filter according to the given specifications.



Results

Our CNN was able to estimate S-parameters with precision of 0.38 dB MAE.
We present our optimized filter, designed to meet the following requirements:

$$s_{11} \leq -15dB \qquad 10.7 \leq f \leq 12.7(GHz)$$
$$s_{21} \geq -0.5dB \qquad 10.7 \leq f \leq 12.7(GHz)$$
$$s_{21} \leq -15dB \qquad 13.7 \leq f \leq 14.5(GHz)$$
$$s_{22} \leq -15dB \qquad 10.7 \leq f \leq 12.7(GHz)$$



Conclusion

We meet our target with a very good approximation.
Additional samples show direct improvement in prediction ability and results. Our project shows a lot of promise and is innovative.