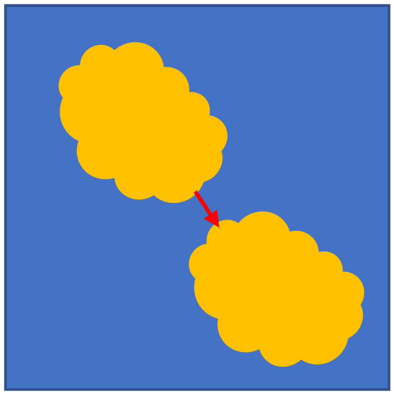
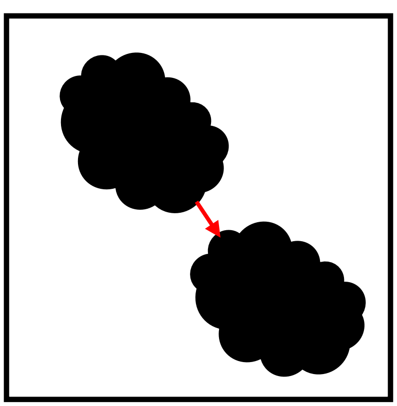
Problem statement: For an antenna geometry represented like in the figure below, how can ones quickly determine if the antenna can achieve certain directivity, gain or input impedance.

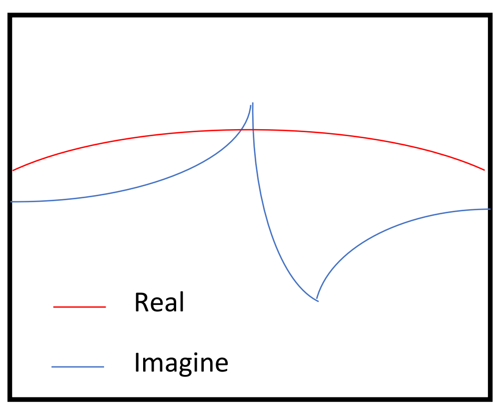


Suggested solution: Applying the convolutional neural network (CNN) just as on pictures to predict the performance. This is just prediction because it should be more correct to run EM analysis like MoM, FEM. The reason for this is rather providing a quick prediction on first-thought design. It can be also independent on the complex calculations of EM simulators, therefore amateur designers can have a free tool to analyze their rather quick simple designs.

Normalization: I believe this is an importance step to simplify the problem and head toward a universal solution. Every antenna designer knows that antenna parameters are variable depending on wavelength (λ). There for there are frequency and these antenna parameter to be normalized. Suppose we are studying a band with center frequency f_0, I suggested to analyze from near 0Hz to $2f_0$Hz. That is to say if an antenna obtains the maximum 100%, it covers an impedance bandwidth from 0-$2f_0$. The antenna structure can be bounded inside a square the size $\lambda/_2 \times \lambda/_2$. This is because we expect dipole to be the one with nearly perfect performance, and its size is around $\lambda/_2$. The study of arrays or effect of parasitic element that sum up the size of the whole system larger than $\lambda/_2$can be the following works.

Concretely, I want to check all designs should be able to be put inside a square the size 1m x 1m, corresponding to $\lambda/_2$ = 1m. This size allows us to expect a center frequency around 1.5GHz ($f_0 = {}^{2c}/_{\lambda}$) . Therefore we check from 0Hz to 3GHz. The input of the CNN is a *grey scale picture* like below.





The size of the input (X) picture is $N \times N$. The feeding mechanism may also need to be defined, e.i. by a vector of 4 points. For example, in this study we want to analyze the effect of antenna geometry on impedance bandwidth. Let's define the output (Y) is a *vector the size $2K$ elements*. The first K elements are real values of the , whereas the second K elements contain imaginary ones.

Assume we can make a database the size M, hence the size of input and output are $M \times N \times N$and $M \times 2K$, respectively. I suppose we can try Gradient decent with shallow network for this case.

Ideas that might improve the calculations:

1. Checking frequency band in logarithmic scale.
2. Including the directivity for the sack of completeness in antenna design. This case the output vector can have the size 2K + 1.
3. This idea in extendable, the more complicated 3D structure can also be study using 3D CNN.