Genetic Algorithm Based Optimazation Technique for Shaping the Matal Pattern of Planer Antenna for mm-Wave Systems

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***Abstract*— In this paper, an antenna for 5G communication systems is designed by a machine-based optimization technique. It is Genetic algorithm that tackles a problem stochastically and is run in the form of automated solution process. The method varies the shape of the metal pattern of the planar antenna and stops the optimization program when it reaches certain level of fitness what we call goal, which is the generation of the resonance at the target frequency. Aimed to enable the antenna to resonate at 28 GHz for 5G wireless connectivity, the shape of the metal pattern of the antenna is decided and taken into evaluation of far-field pattern as well as input port impedance matching.**

Keywords*— *5G Communication, Antenna, GA, Optimization

I. Introduction

Millimeter-wave technologies are expected to play a vital role for 5G and 6G communication technology. Though there are a lot of important parts and modules for a 5G wireless system, it is needless to say that one antenna or many are essential to let high frequency signals from the transmitting system to the receiver one. The reason why the antenna should be developed to form an invisible but existing channel between one pair of communication nodes or more such as MIMO [1-2]. Fig. 1 shows the picture of a 5G base-station antenna, its model adopted in the electromagnetic simulator, and its elemental structure [3]

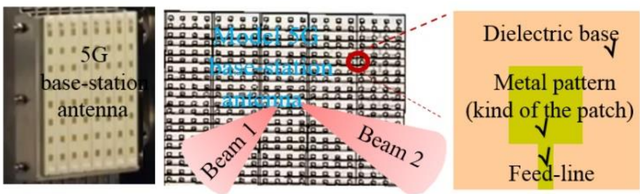


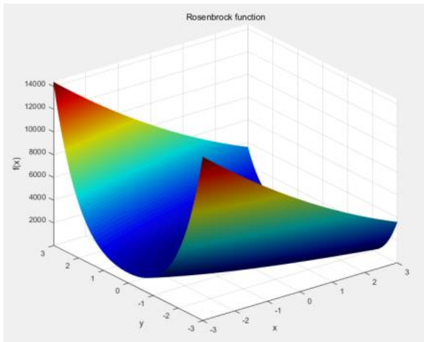
Fig. 1. MIMO Antenna System

As is pursed in 5G mobile service, an antenna is responsible for conveying the mm-wave signals to the air and catching the incoming signals into the system. The array antenna which is known to make beamforming possible consists of the elemental radiating structure as seen on the rightmost side of the figure above. The signals propagate as electromagnetic fields and waves and they become strong and smoothly continue through the interface from the dielectric base to the air when it hits the resonance condition at the target frequency. Unlike deterministic ways [4-5]. GA based shaping of the structure is tried as an alternative way.

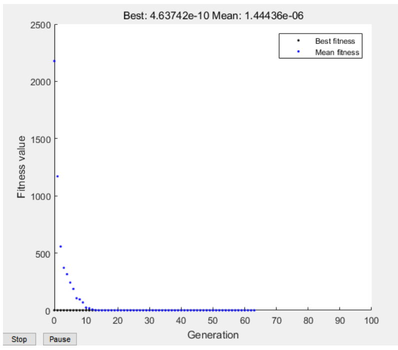
II. EBG Structure Design Using GA for 28 GHz Patch Antenna

Ahead of real application, we need to check if our algorithm as a computer program works well as others do. It is applied to a 2D nonlinear function as a Rosenbrock test.

$$f(x, y) = 100(y - x^2)^2 - (1 - x)^2 \qquad (1)$$



(a)



(b)

Fig. 2. GA finds a global minimum of a 2D non-linear problem (a) Functional behavior (b) Error goes down as the solution converges

Eq. (1) is given to the computer which does not have where the minimum point is located. Fig. 1(a) shows how the function is unfolded. Fig. 1(b) is the change of the error function. This assures us of the ability of the algorithm we adopt to an antenna problem. The geometry of the elemental antenna is shown in Fig. 3. The antennas is printed on Rogers-5880 substrate with a thickness of 0.254mm. The relative permittivity is 2.2. The length of the substrate l_{sub} is 14 mm, and Width w_{sub} = 6 mm. It uses the feed-line .

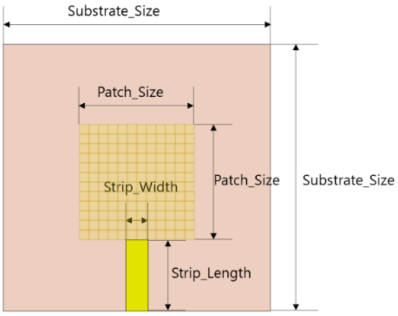


Fig. 3. Structure to be optimized

As it is shown, the patch of the antenna of Figure 1 is expressed as the mesh grid. The equally spaced meshes or pixels are painted metal or dielectric by the generation part of the GA process adopted here. The zoomed version is given in the following figure.

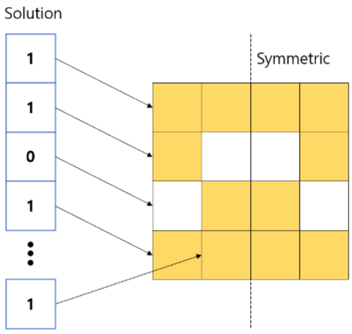


Fig. 4. Generation or removal of the metalization

The meshes can be metal. When the entire target area is given 1, it is filled with metalization. Otherwise, the pixels assigned 0 will be non-metalized spots in Figure 4.

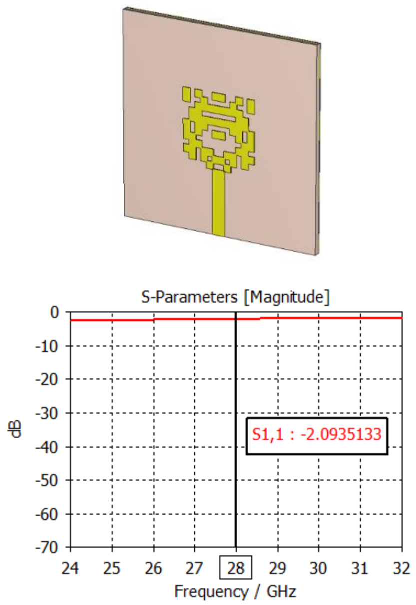


Fig. 5. Initial stage has this incomplete geometry and poor impedance matching violating the resonance condition

Using the random number generation within the GA process, the numbers 1 and 0 are given to the string of pixels and they are mapped to the problem area. The initial stages, the first generation makes the shape of the metal patten of the antenna and S_{11} as the reflection coefficient. Figure 5. A very high reflection means poor impedance or violation of the resonance condition for 28 GHz operation. This will be improved by the following chart showing the performance of the GA solution procedures.

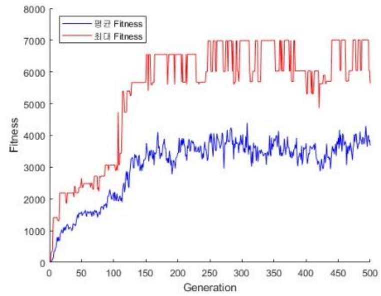


Fig. 6. Convergence curves of the optimal parameter sets

From generation to generation, the fitness function goes increasing and reaches the level of convergence. The fitness function prescribed to make S11 the lowest at 28 GHz makes the very low error between the desired and tried values.

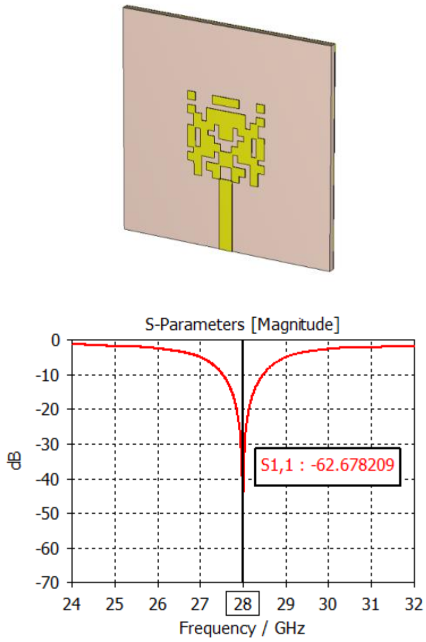


Fig. 7. Finalized structure and its performance

Fig. 7 presents the finalized version of the metal pattern of the antenna. Watching S11, the impedance is matched at the port of the feedline and accomplishes the resonance condition.

III. CONLCUSION

Genetic Algorithm based antenna design optimization structure is a core of hardware systems of 5G communication. The pixels of the metal pattern of the antenna are filled with metal and dielectric material according to the lowering of the error function inverse of the fitness function.

IV. ACKNOWLEDGEMENT

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