The Intelligent Algorithm for sweet spot (ICCAS 2003)

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Abstract: Millimeter-wave networking is composed of narrow beam link. it is very substantial that beam connecting point to point is fixed in right direction. It is major requirement in the beam network to keep the beam in best direction. In this paper, We propose the method to find a best suited direction of the antenna's beam using the Genetic Algorithm (GA) in point-to-point link. Proposed method presume that each station knows his direction Θ_1 , Θ_2 at every step of GA, then it can be expected that GA is possible to search the ideal solution.

Intensity of the received signal is evaluated by the multiplication of lengths to the point which the lobe meets with the horizontal line.

Keywords: sweet spot search, Genetic Algorithm, beam, antenna

1. INTRODUCTION

The millimeter – wave have been raised to the alternative of a need sudden increase about frequency proxy to be restricted. A market growth which is the explosive is predicted in a millimeter – wave relation system[1] [2].

Millimeter-wave networking is composed of narrow beam link. High directivity of the beam provides either advantage or disadvantage in comparison with conventional wide-lobe microwave communications. In such networks, it is very substantial that beam connecting point to point is fixed in right direction. Consider practical situations to adjust the satellite broadcasting antenna by manual operation, such work is very critical and leaves risk of unexpected disconnection or SNR reduction. It is major requirement in the beam network to keep the beam in best direction [2] [4].

This paper proposes the method to find a best suited direction of an each station using GA in point to point link.

Supposing the point to point connection, let us adjust both sides of antenna so that each station receives signal in maximum intensity. Such adjustment should be accomplished in blind manner that each station does not know only his best direction but also partner's best direction. However, we have a key to solve this problem, i.e. both stations are possible to have common information about intensity of the received signal and control signal of antenna at both sides.

2. STRATEGY

2-1 Model of the problem

Figure 1 shows an ideal situation that each station receives the signal in maximum magnitude. Intensity of the received signal is evaluated by multiplication of length of two lines. Figure 2 and 3 show cases that antenna turns around to wrong direction, where signal intensity at each side is calculated also by multiplication of length of lines. Note that both stations receive same magnitude of electro-magnetic wave[4].

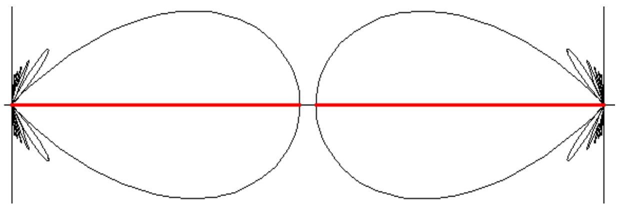


Figure 1. The ideal situation

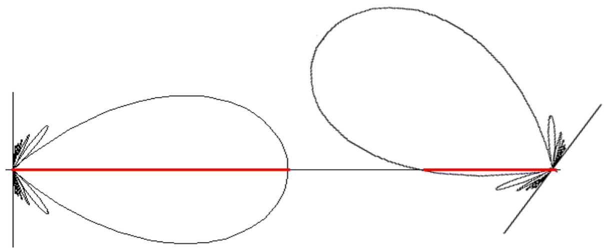


Figure 2. Right hand side station turns to wrong direction

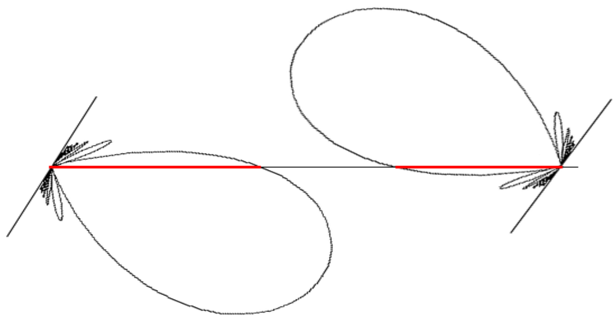


Figure 3. Both stations turn around to wrong directions

2-2 Formulation of the problem

Let angles from horizontal line be θ_1 and θ_2, then lengths of two red lines are given by [4]

$$r_1 = J(\pi D / \lambda \sin(\theta_1)) / (\pi D / \lambda \sin(\theta_1)),$$

$$r_2 = J(\pi D / \lambda \sin(\theta_2)) / (\pi D / \lambda \sin(\theta_2))$$

where J is the first order Bessel function, D and λ are diameter of antenna and wavelength respectively. The multiplication r_1, r_2 is a function of θ_1 and θ_2, whose figure is illustrated as follows.

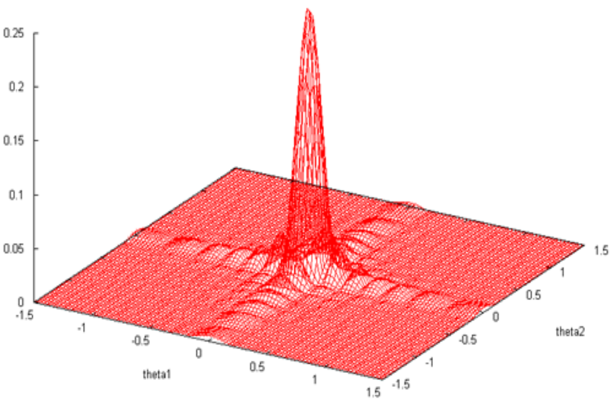


Figure 4. The multiplication r_1, r_2

2 - 2 **Application possibility of the Genetic Algorithm**

Our destination is to go up to the most suitable solution, i.e. peak of the figure. Presume that each station knows his direction θ_1 or θ_2 at every step of GA algorithm, then it can be expected that GA is possible to search the ideal solution. This paper simulates under this assumption.

Practically, the station cannot know such absolute axes as line connecting both stations. To design the strategy without such absolute axes is a further problem.

3 . GENATIC ALGORITHM

The GA is a model of machine learning which derives its behavior from a metaphor of the processes of evolution in nature.

This is done by the creation within a machine of a population of individuals represented by chromosomes, in essence a set of character strings that are analogous to the base-4 chromosomes that we see in our own DNA. The individuals in the population then go through a process of evolution[3].

PSEUDO CODE

```
GA is

// start with an initial time
        t := 0;

// initialize a usually random population of individuals
        initpopulation P (t);

// evaluate fitness of all initial individuals of population
        evaluate P (t);

// test for termination criterion (time, fitness, etc.)
        while not done do

// increase the time counter
        t := t + 1;

// select a sub-population for offspring production
     P' := selectparents P (t);

// recombine the "genes" of selected parents
        recombine P' (t);

// perturb the mated population stochastically
        mutate P' (t);

// evaluate it's new fitness
        evaluate P' (t);

// select the survivors from actual fitness
        P := survive P,P' (t);

end GA.
```

4 . SIMULATION PROCEDURE

4 - 1 **Outline of the program**

At initial stage, 40 times of random change of angle at each side are processed. GA selects 40 pairs of angle at random among 40*40=1600 pairs. It should be noted that we employ an impractical assumption that exact values of these angle pairs are known each other.

4 - 2 **Flow chart of the program**

The flow chart of the program is illustrated as follows.

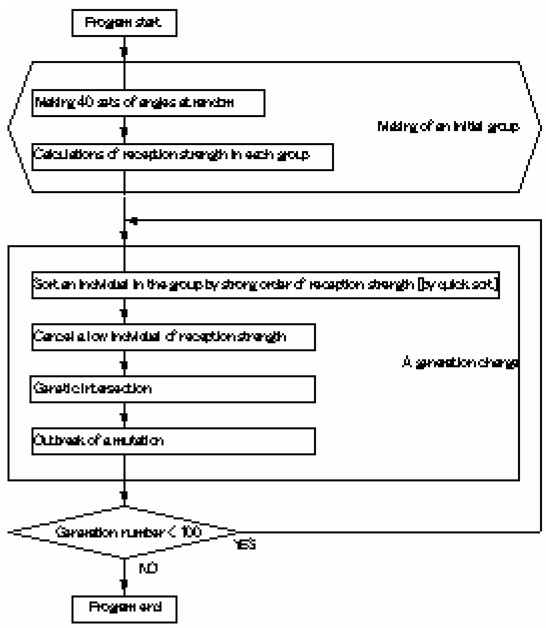


Figure 5. The flow chart of the program

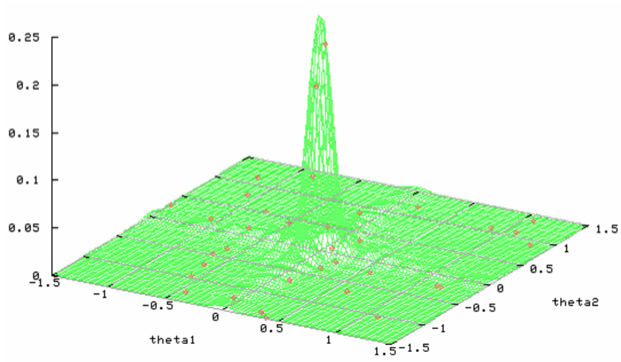
5 . SIMULATION RESULTS

A hundred generations ware simulated in cartoon film, and we confirmed that angle pairs always gather at peak of the intensity figure. It was observed that progress of generation depends strongly upon initial group.

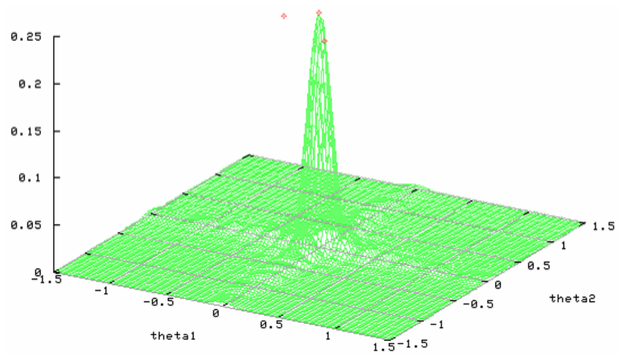
5 - 1 **Simulation results 1**

Generation progress is displayed in intermittent way here (see the animations at address shown in last of this report). We can see that some individuals are scattered by mutation and at 20th generation most of individuals go up to the peak.

First generation



No.20 generation



No.100 generation

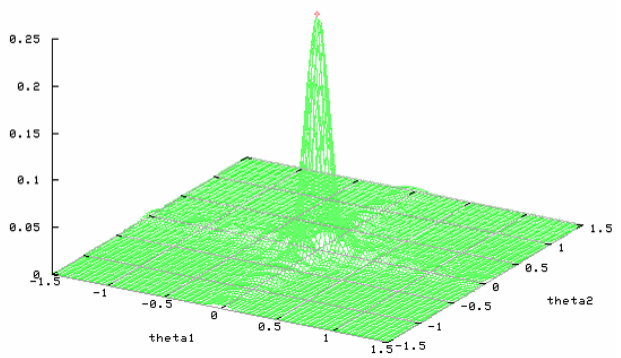
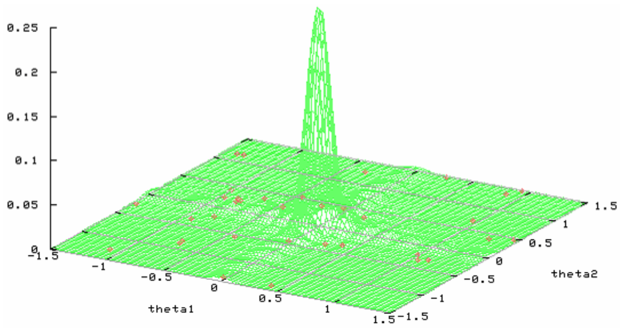


Figure 6. CASE 1

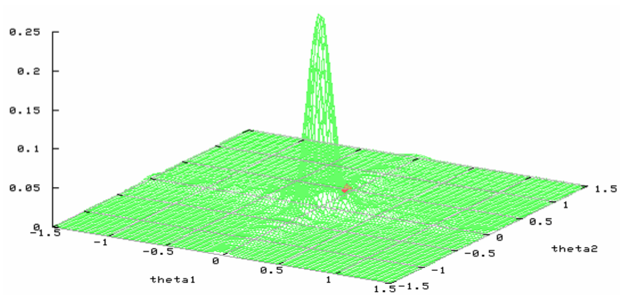
5 - 2 **Simulation results 2**

This example shows the case that all individuals fall into local solution. Everyone stays at root of the peak before 60th generation and goes up to peak by mutation outbreak at 60th generation.

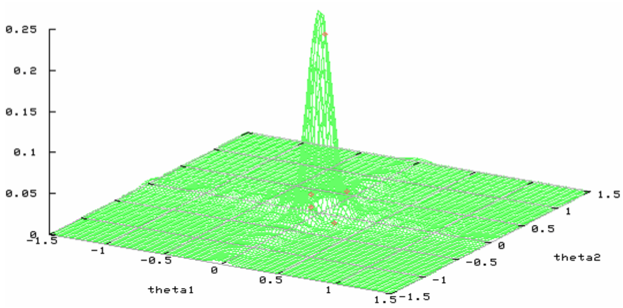
First generation



No.6 generation



No.60 generation



No.100 generation

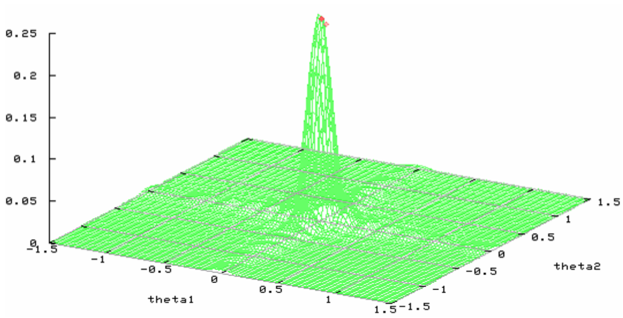


Figure 7. CASE 2

5 - 3 Simulation results 3 (Optimum initial group search)

The previous simulation was observed that progress of generation depends strongly upon initial group. To improve the risk of long stay at local solutions, We propose the following method.

We make several initial groups and select optimal group. Then the optimal group is used initial group. This method reduced a risk of long stay at local solutions[3].

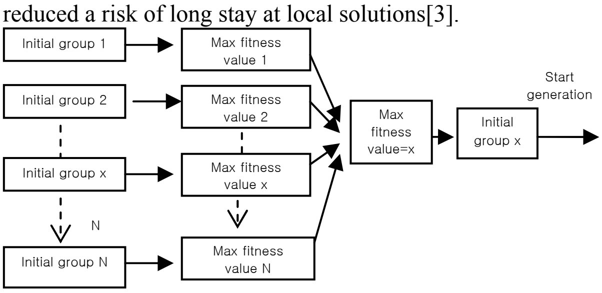


Figure 8. Block diagram of optimum initial search

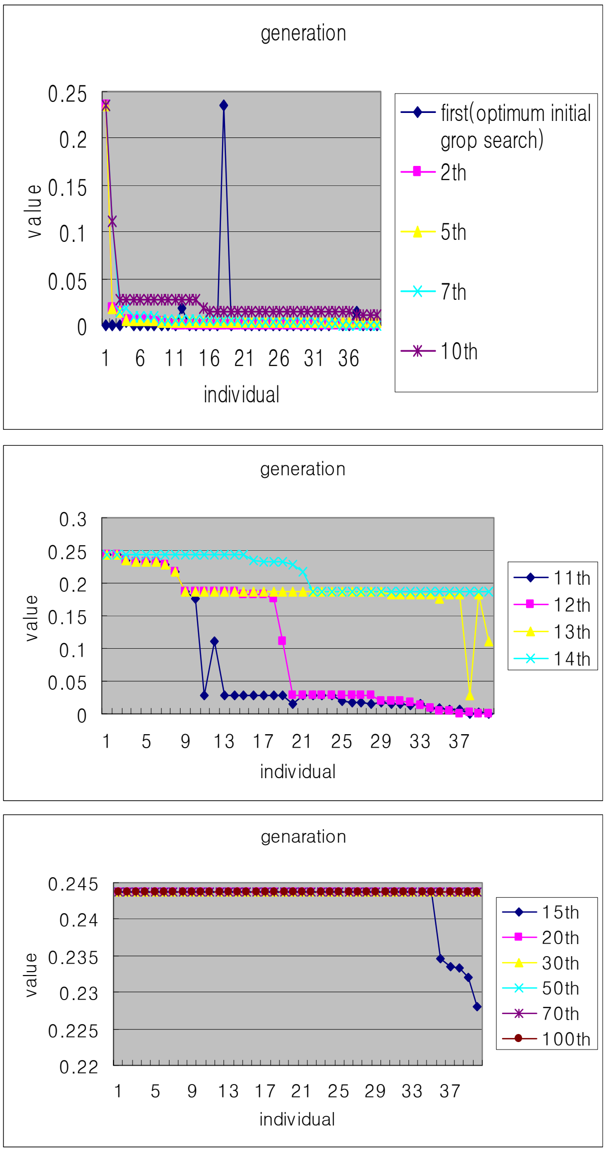


Figure 9. simulation results.(CASE 3)

6 Conclusions

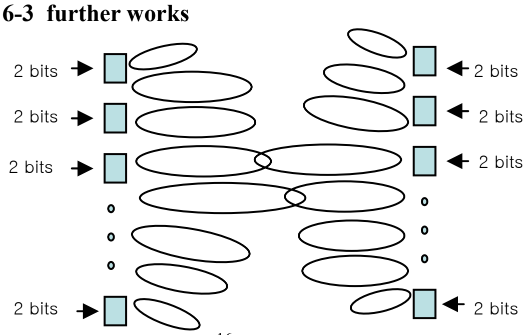
6-1 Remarks

GA has a risk of long stay at local solutions. In above simulations, such long stay waiting mutation outbreak is frequently observed. The simulation was performed under impractical situation that each angle in geometrical sense is known at each side. However, such angle cannot be defined without a priory given axes. In practical situations, we can take nothing but signal to control direction of antenna, where the direction is usually non-linear function of the control signal.

6-2 Issues

- To improve the conventional elite strategy
- To find more intelligent mutation strategy
- Application of GA to cases that the station does not know the direction of opposite station
- Application to more practical cases that only the control signal of antenna is informed each other.
- Treat of more complex intensity figures unlike as figure 1 Study of GA in combination with other AI algorithms

6-3 further works



- Each station has 2^{16} lobe patterns
- The total number of lobe combinations becomes $2^{16}*2^{16}=2^{32}$.
- Both antennas must be jointly controlled and severs two-way protocol is required under weak SNR conditions.
- Intensity of the received signal and state of all genes should be informed each other to progress the generation. It will be better to employ the spread spectrum coding to overcome weak SNR conditions.
- By developing a method of a priory categorization of lobe patterns, it may be possible to find more reliable and high speed "hierarchical genetic algorithm,"[5].

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