Antenna Diversity using Particle Swarm Optimization

Rajesh Kumar, Dr. S.S.Pattnaik and Swapna Devi,

Educational Television Centre & Electronics and Communication Engineering Department, National Institute of Technical Teachers’ Training and Research, Sector-26, Chandigarh-160019, INDIA
Tel.+91987297362
Email: headetv@yahoo.co.in

Abstract- Particle swarm optimization technique is a soft computing approach and has many Engineering applications. In this paper the optimization technique viz., Particle swarm optimization is used to calculate separation between antennas. Space diversity method is based upon the principle of using two or more antennas in order to receive uncorrelated radio signal. By doing this, there is a possibility of combining the antenna outputs so that the fading can be avoided. To minimize fading of a signal and to calculate spacing between antennas, we use Particle swarm optimization technique.

Index terms-Evolutionary computing(EC), GA(genetic Algorithm),PSO (particle swarm optimization),social behavior, space diversity.

I. INTRODUCTION

Particle swarm optimization is a concept that was conceived by Kennedy, J. and Eberhart, R. C. in year 1995 [1]. The technique is based on social behavior of animals and insects. Movement of particles (birds) consumes energy; so they move in best-optimized path to gain more energy than they losse. The optimized path that is being used by particle forms the basis for optimization algorithm i.e. Particle Swarm Optimization technique, which is used in optimizing many engineering problems. In this paper, this optimization scheme is used in space diversity scheme for determination of separation between antennas. Optimization is to seek values for a set of parameters that maximize or minimize objective function(s) subject to certain constraints [2]. A choice of values for the set of parameters that satisfy all constraints is called a feasible solution.

Feasible solutions with objective function value(s) as good as the values of any other feasible solutions are called optimal solutions.

The main difference between the PSO approach compared to EC and GA is that PSO does not have genetic operators such as crossover and mutation [3]. Particles update themselves with internal velocity; they also have memory that is important to the algorithm. Compared with EC algorithms such as evolutionary programming, evolutionary strategy and genetic programming, the information sharing mechanism in PSO is significantly different. In PSO, only the ‘best’ particle gives out the information to others. It is a one-way information sharing mechanism, the evolution only looks for the best solution [4]. Compared with Evolutionary Computing, all the particles tend to converge to the best solution quickly even in the local version as in most cases. Compared to GA, the advantages of PSO are (i) PSO is easy to implement and (ii) there are few parameters to adjust [5].

A diversity scheme is a method that is used to develop information from several independent fading paths. This means that the diversity method requires a number of transmission paths called multipath. A single receiving antenna can not compensate the problems arises due to multipath distortion. To compensate these problems space diversity receivers, having multiple array antennas, are used. Under the condition an adaptive approach is required that can adjust the antenna spacing according to the changing environmental conditions so that
the required signal condition is achieved at the receiver.

II. IMPLEMENTATION OF PSO IN SPACE DIVERSITY

For a traditional longhaul telecom link a preferred goal for path availability is 99.999%, referred to as the “five-nines” [6]. The availability “A” is expressed as

\[ A = (1 - \text{Fade Probability}) \times 100 \quad \ldots \ldots (1) \]

The fade probability \( P_f \) under most conditions is given by

\[ P_f = 2.5 \times 10^{-6} \times a \times b \times D^3 \times f \times 10^{-\left(M_f/10\right)} \quad \ldots \ldots (2) \]

However, this expression does not contain the improvement factor that space diversity can offer.

The space diversity improvement factor \( I_{sd} \) modifies the fading probability as follows [6].

\[ I_{sd} = \frac{7 \times 10^{-5} \times S^2 \times f \times 10^{M_f/10}}{D} \quad \ldots \ldots (3) \]

The improved fade probability \( P_{sd} \) is then expressed as

\[ P_{sd} = \frac{P_f}{I_{sd}} \quad \ldots \ldots (4) \]

Using equation (3) and (4), we derive the formula for separation between antennas as

\[ S = \left[ \frac{3.57 \times 10^{-2} \times a \times b \times D^4 \times 10^{-\left(M_f/5\right)}}{P_{sd}} \right]^{-1/2} \quad \ldots \ldots (5) \]

Where

- \( D \) = path length in miles
- \( f \) = frequency in GHz
- \( a \) = terrain factor
- \( b \) = climate factor
- \( M_f \) = fade margin

There are two ways to maximize the Availability (A), by choosing high \( M_f \) which is dependant on the system parameters. This direct approach is not a perfect choice.

Another way is to improve the Availability (A) with the help of space diversity improvement factor that reduces the fade probability. This selection is based on optimal spacing between antennas.

The selection of antenna spacing is done by experimenting and finding the spacing between antennas [6]. But this limit adaptive selection in intelligent system or in smart system. Therefore, in this paper antenna spacing is calculated using PSO. This gives an adaptive selection of antenna spacing based on fade margin and terrain conditions in a space diversity system.

In the present paper, we use the derived equation (5) as the cost function of PSO to calculate the antenna spacing for varied fade margins. The results are compared with experimental findings of Ref. [6], which are in good agreement.

III. RESULTS AND DISCUSSION

Fade probability decreases with increased fade margin. For getting the high availability, the value of fade probability must be lowered which means higher fade margin. Figure (1) shows the antenna spacing obtained through experimental Measurements for varied fade margins.

![Fig.1. Fade Margin versus Fade probability for different S](image-url)
applied to calculate the spacing between antennas for a fade margin of 40 dB. Figure (2) shows the result of the proposed method where the antenna spacing is found to be 30.35 feet i.e. the error is of 1.17 %.

When the proposed method is applied for a fade margin of 36 dB, 32 dB and 30 dB the antenna spacing are found to be 26.61 feet with the error of 3.05 %, 46.32 feet with the error of 2.89 % and 71.64 feet with the error of 2.34 % respectively. Figures (3) to (5) depicts the outputs of the proposed PSO based technique.

As seen from the results, the findings are in good agreements with the experimental values thus, inspiring to explore the possibility of using the proposed algorithm in antenna diversity to calculate the spacing between antennas.

III. CONCLUSION

We proposed a method to use PSO for calculating antenna spacing in space diversity. The results are compared with the published experimental results and are found to be in good agreement. The proposed soft computing approach seems to be a quicker, easy, accurate and low cost method to calculate antenna spacing in space diversity scheme. The method can be exploited to be used in adaptive smart antenna system to adjust the antenna spacing in varied terrain and atmospheric conditions i.e. with varied fade margin.

REFERENCES


