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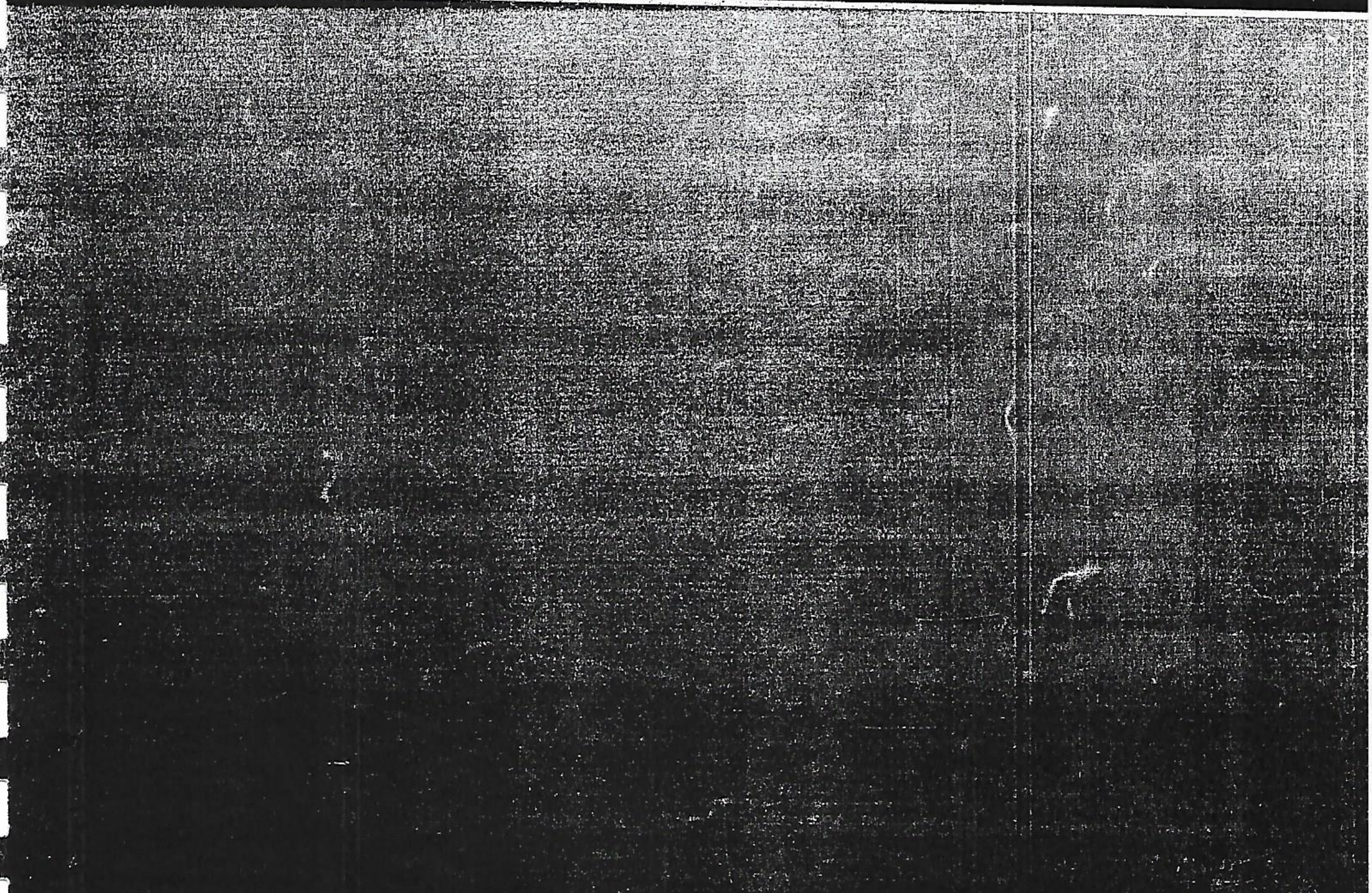

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Optimization of Power Control in Mobile Multimedia Communication Systems in Hospitals using Genetic Algorithm

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ABSTRACT

Background: The rapid growth in cellular radio communications necessitates more efficient utilisation of spectrum. This is more so in medicine where very large volume of data and information are involved. The increased sharing of spectrum due to this growth translates into a higher likelihood of users interfering with one another. So cell capacity is inherently interference limited, particularly by co-channel interference (CCI) and adjacent channel interference (ACI).

Objective: One of the solutions to combat these interferences is to control of power. Two types of power control are used in wireless network communication systems: centralised power control (CPC) and distributed power control (DPC). Centralised power control is computationally very complex for large systems as it assumes that all information about the link gains is available to all mobile devices. DPC, unlike CPC, requires only local information to adjust power levels of each transmitted signal. DPC is therefore more realistic when the number of mobiles grows and will be used as the foundational system model in this work.

Methods: Many optimisation techniques have been used for distributed power control system models. However, the techniques have been restricted to the traditional optimisation methods which use the characteristics of the problem to determine the next sampling point. In this work, Genetic Algorithm GA, an evolutionary approach is used. It follows the concept of evolution by stochastically developing generations of power-solution populations based on a fitness score.

Results: It can be seen that the convergence speed of GA is not as fast as that of the conventional method and consequently a higher outage probability. The simulation results show that GA is more robust, more realistic performance, very proactive to noise, fading or shadowing

Conclusion: A genetic algorithm responds and adapts to this change on the fly but many traditional optimisation procedures must restart afresh which is computationally expensive.

Keywords: Distributed Power Control, Genetic Algorithm, Optimization, Multimedia System

INTRODUCTION

The distributed power control problem is viewed as a typical optimisation problem where the objective function (to be minimized) is the DPC system model, the unknown variables are the transmit powers of each of the sixteen users, and the constraint is that there is a transmit power range within which the users' power must remain.

Thus the objective function is as given as:

$$\gamma_i = \frac{P_i}{\sum_{j=1}^{K} P_j Z_{ij} - P_i + \frac{n}{G_{ii}}} \qquad (1)$$

Since 16 users are being considered, the vector form of the objective function is preferred as in

$$\gamma = \frac{\mathbf{P}}{\mathbf{P}_j \mathbf{Z} - \mathbf{P} + \mathbf{N} / \mathbf{G}} \qquad (2)$$

where $\mathbf{P}$ is the mobile users' power vector $(P_1, P_2, ..., P_i, ..., P_{16})$. $\mathbf{N}$ is the receiver noise vector $(n_1, n_2, ..., n_i, ..., n_{16})$. $\mathbf{G}$ is a diagonal matrix $(G_{11}, G_{22}, ..., G_{ii}, ..., G_{1616})$. $\mathbf{P}_j$ is the power vector of the co-channel interferes. $\mathbf{Z}$ is the normalized uplink gain matrix computed using (3) :

$$Z_{ij} = \begin{cases} \frac{G_{ij}}{G_{ii}} & if \quad j \neq i \\ 1 & otherwise \end{cases} \quad \text{and} \quad G_{ij} = \frac{A_{ij}}{d_{ij}^{\beta}} \qquad (3)$$

thus results in a 16 by 16 matrix that is fundamentally dependent on the distances of all the interfering co-channel users from the base station of the cell of interest. The distances of mobile users from their respective base stations are different and so were randomly generated. The diagonal of which results to unity corresponds to the normalised link gains of the desired communication links. The genetic algorithm toolbox is essentially used to find the power vector that achieves minimum required CIR value of 13 dB -typical GSM standard [15] -for all the 16 mobile users, i.e. CIR balancing. The power control variable is encoded as the chromosomes (individuals) within the constraint of 1 2 for 1.

In the Zander's case[9], this is a CIR based DPC algorithm which starts with an arbitrary transmitter power vector of all the active co-channel users in the system. The CIR level is estimated in each link at the receiver, and the result is reported back to the transmitter by the DPC algorithm. The mobile then adjusts its power in the following way [2,9]:

$$P_i^{k+1} = \beta P_i^k \left(1 + \frac{1}{CIR_i^k}\right) \tag{4}$$

Where is a parameter that is selected as [1 & 10]

$$\beta = \beta(k) = \frac{1}{\|P^k\|} \tag{5}$$

$\|P^k\|$ represents the norm of p^k and CIR_i computed as in (1) but with noise not included

$$\gamma_i = \frac{P_i}{\sum_{j=1}^{K} P_j Z_{ij} - P_i} \tag{6}$$

The above Zander's algorithm was subjected to the same simulation environment/condition as genetic algorithm based DPC and the results obtained and compared as shown in the graphs below.

MATERIALS AND METHODS

Applying GA to distributed power control basically involves bringing to a common point the system model of DPC and the MATLAB Genetic Algorithm tool box. A system of 16 co-channel cells is considered in an uplink scenario. In other words, recalling K is 16. This implies that the number of mobile users in the co-channel set will also be 16 since the channel pair is used only once in each cell in the set. The users are at different distances from their respective base stations and the same radius of 2 km is chosen for all cells. 16 co-channel cells and 2 km radius are chosen so as to achieve realistic comparison since the same parameters were used in Zander's conventional method [8 & 9] (results of which are compared with those of GA in this thesis). These cells arranged in a hexagonal grid and housing their respective users are placed on a two dimensional plane where users' distances from base stations are estimated using x and y coordinates as reference points.

RESULTS

The convergence results of the conventional and GA methods are shown together for ease of comparison in Figure 1 to Figure 6. It can be seen that the convergence speed of GA is not as fast as that of the conventional method (compare Fig 1 and Fig 4) and consequently a higher outage probability (Fig 3 and Fig 6). Where Zander's conventional method converged after 68 iterations the genetic algorithm based method converged after 120 generations (1iteration is assumed to be equal to 1 generation since the GA function evalFN in GAOT implements a generation in form of iteration). The outage probability is also shown to be higher in GA than in Zander's conventional method (see Figures 3 and 6). The reason can be found in the fact that genetic algorithm search is intrinsically probabilistic and is neither guided nor specifically optimized like the above conventional method to solve DPC problem. Recalling section the fact that GA uses objective functions makes it very robust but denies it of specific knowledge about problems it intends to solve hence placing an upper bound on its performance when compared with specialized methods designed for that particular problem as in the case above. However, a genetic algorithm has some advantages over the traditional methods in distributed power control scheme as observed in the course of this research.

Comparison Graphs of Genetic Algorithm's performance on distributed power control and that of Zander's conventional CIR-based Algorithm

Table 1
Considered Variant of GA Parameters

Case	Crossover	Selection	Mutation
1	Arithmetic	Ranking	Boundary
2	Arithmetic	Roulette wheel	Non uniform
3	Arithmetic	Ranking	Non uniform
4	Heuristic	Roulette wheel	Non uniform
5	Simple	Ranking	Non uniform
6	Simple	Ranking	Uniform
7	Heuristic	Ranking	Non uniform

Results of Conventional (Zander's) method

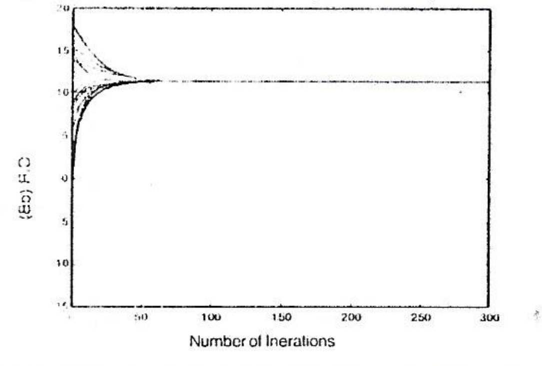

Fig 1: CIR convergence/balancing over iterations

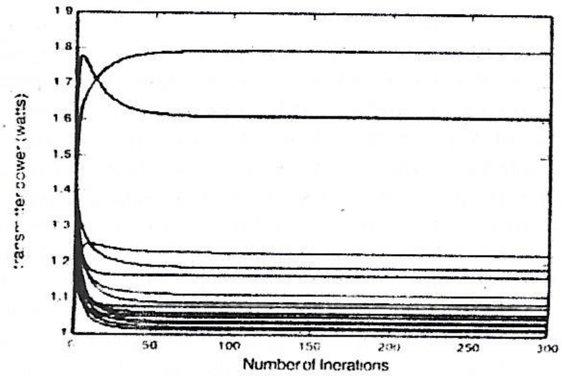

Fig 2: Power solutions controlled over iterations

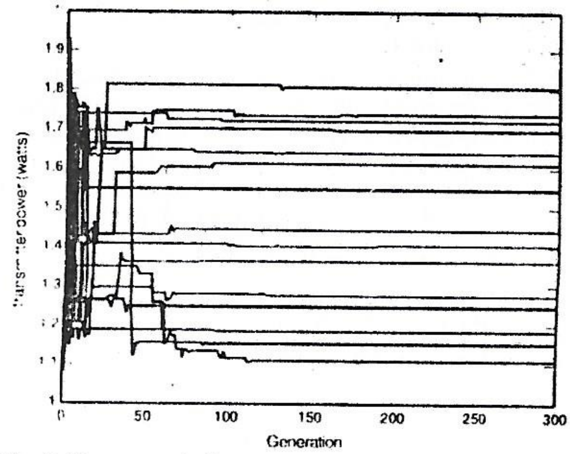

Fig 5: Power solutions controlled over generations

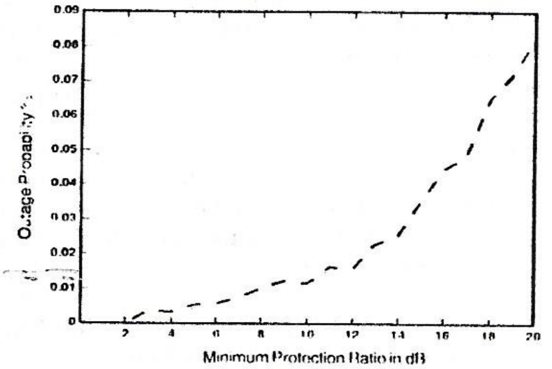

Fig 3: Outage probability for CIR-based DPC algorithm – Zander's method

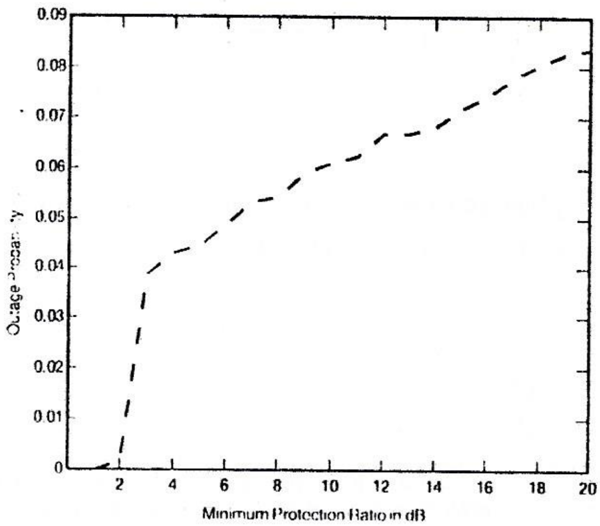

Fig 6: Outage Probability for CIR-based DPC algorithm – GA method

Results of genetic algorithm-based(GA) method

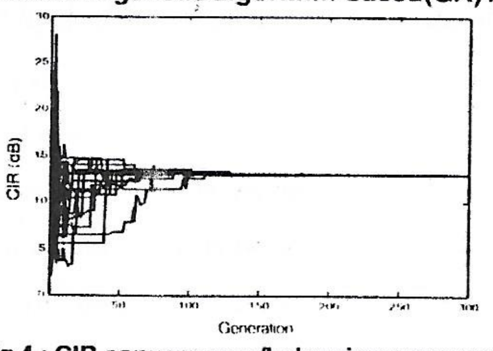

Fig 4 : CIR convergence/balancing over generations

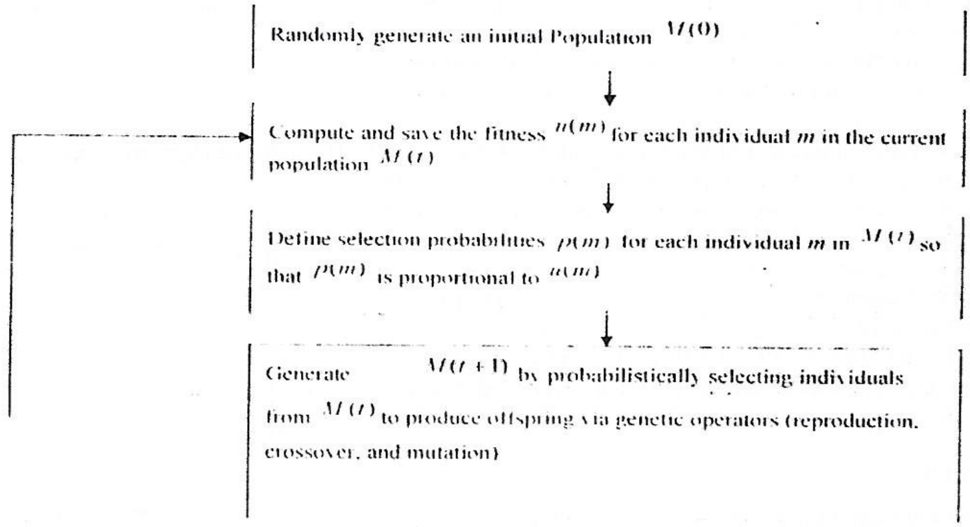

Figure 7: A generic Genetic Algorithm [8]

DISCUSSION

Seven case were tested. In each of the seven cases, two graphs are drawn. The first, Fig 4 shows the convergence of CIR values of all the users to the required minimum of 13 dB for the GA parameter variants being considered in the particular case. Hence it represents the CIR value of each user as generation changes. Similarly, Fig5 shows how users' transmitter powers were controlled over generations to achieve the CIR convergence. Each line thus represents the transmitter power value of each user as generation changes. These formats are the same for cases 1 through 7. They are also maintained in Figure 1through 6 where GA is compared with Zander's method.

Comparing the results of cases 1, 2, and 3, it can be seen that among the three different mutation/selection combinations run with arithmetic crossover, non uniform/ ranking (case 3) gave the best performance. Case 1 converged but with less focus as many users' CIR were only around 13 dB. Case 2 (Non uniform/roulette wheel) gave a poor performance where there was also no focussed convergence as in case 1 and one user's CIR did not converge. The implication of results in cases 1 and 2 is that power will not be optimally conserved and calls will be dropped (higher outage probability). Case 2 was repeated in case 4 but now using heuristic crossover and the result showed a remarkable improvement though the convergence is still not improved. In test cases 5 through 7, where different combinations of mutation and crossover operators were run with ranking selection technique, test case 6 performed relatively poorly compared with 5 and 7. The users CIR did not at any point converge pointedly to 13 dB making it ineffective. The performances of cases 5 and 7 were very good as convergence was very focussed in both cases.

It is interesting to note that all the three test cases that performed well (3, 5, and 7) have the same type of mutation operator/selection technique combination. That is Non uniform mutation combined with ranking selection. This superior performance can be fundamentally traced back to ranking selection technique where the population is first sorted according to the objective values and then the fitness assigned to each individual depending only on its position in the individuals rank and not on the actual objective value. This overcomes the scaling problems of the proportional fitness assignment used by the rival roulette wheel selection technique. Consequently, applied to distributed power control in this work, ranking selection behaved in a more robust manner than roulette wheel and produced a better result.

The above observations suggest that a genetic algorithm which utilizes Arithmetic crossover, Non uniform mutation, and Ranking selection technique will perform best in distributed power control scheme.

CONCLUSION

GA's random and multiple search approach enables it to produce counter intuitive solutions. With GA, no 'good' power solution was intuitively chosen and started from as would be done in most traditional methods. In the case Zander's conventional method a random search-start-point (power solution) was chosen whereas the GA approach generated random multiple search-start-points; in this case eighty (population of individuals). Thus the convergence speed of the above conventional method is highly influenced by how close the randomly chosen search-start-point is to the global minimum. This is not the case in the GA approach. Finally, in a real life DPC application of genetic algorithms, its robust nature becomes a huge advantage in a typical dynamic power control environment where sudden change or discontinuity is common due to fading or shadowing. A genetic algorithm responds and adapts to this change on the fly but many traditional optimisation procedures must restart afresh which is computationally expensive.

REFERENCES

1. Rabee, S.A., Sharif, B.S., and Sali, S., An Efficient Algorithm for Distributed Power Control in Cellular Radio Systems. IEE 3rd International Conference on 3G Mobile Communication Technologies, 2002; 123-127.
2. Cheng, S. and Cox, D. Integrated Power Control and Beam-forming in TDMA Cellular Systems with Mobility. IEEE Vehicular Technology Conference, 2001; 1498-1502.
3. Yun, L. Power Control for Cellular Systems. Published by Kluwer Online, www.flipper.ncl.ac.uk/wireless
4. El-Osery, A, and Abdallah C, 'Power Control in CDMA Cellular Systems', Tech online Education, www.techonline.com.
5. Pichna, R, Wang, Q. and Gibson J.D. (ed.). The Communication Handbook, CRC Press. Massachusetts, USA, 2002.
6. Lv, L., Zhu, S. and Wang, Y. A Distributed Power Control Algorithm for Wideband CDMA Cellular Mobile systems, www.ifip.or.at/con2005
7. Hongyu, W, Rong, H. Aiping, H. and Weikang, G. A Distributed Power Control Algorithm for Cellular Radio Systems: www.ifip.or.at/con2000/icct2000/icct017.pdf
8. DeJong, K.A., 'Genetic Algorithms are NOT Function Optimisers,' In L.D.Whitley (ed.), Foundations of Genetic Algorithms.2, Morgan Kaufmann, California, 1993.
9. Zander, J., 'Distributed co-channel interference control in cellular radio systems', IEEE Trans. Veh. Technology, Vol. 41, No. 3, August 1992, pp.305-311.
10. Chamberland, J. and Veeravalli, V., 'Optimal Dynamic Power Control for CDMA Systems', [Online] Available www: http://tesla.csl.uiuc.edu/Conferences/isit2005.pdf