Quest Journals
Journal of Software Engineering and Simulation
Volume 8 ~ Issue 7 (2022) pp: 71-76
ISSN(Online) :2321-3795 ISSN (Print):2321-3809
www.questjournals.org

Research Paper

Optimization of Location of Electrodes in Human Cochlea for Blue Hearing System

Parul Saxena
Department of Computer Science,Soban Singh Jeena University, Almora, 263601, Uttarakhand, India

ABSTRACT: *Blue Hearing System is the artificial hearing system for deaf and mute.* ***.*** *In the present study the positionsof electrodes to be implanted in the cochlea of deaf and mutefellow have been optimized using Particle Swarm Optimization method.The famous greenwood equation has been considered to design the fitness function for position optimization. The frequency is triggered using appropriate level at the mapping time of the patient. We have compared the results obtained by particle swarm optimization for varying patient's anatomy with the actual values using Greenwood equation.*

KEYWORDS: *Blue Hearing System, Particle Swarm Optimization, Greenwood equation, Fitness function, length of corti*

R*eceived 06 July, 2022;* ***R****evised 18 July, 2022;* ***A****ccepted 20 July, 2022*
P*ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

In all real life problems as especially in medically solvable problems, optimization of various parameters is very important. Our algorithm should be capable enough to provide the best solution at the cost of minimum time and resources. In case of many medical applications of optimization problems we compromise with the cost for better accuracy for unambiguous diagnosis. Blue Hearing System is the substitute system for the deaf and mute people to provide them hearing sense and to develop speech in consequence by adopting a proper speech therapy treatment. By using cochlear implant surgery the patient can be made worthy to hear and to make response towards various sounds. In this implantation an electrode array is inserted into the tympanic ramp of the patient's cochlea in the Scala tympani.This array of electrodes stimulates the auditory nerve system which is the substitute way of hearing [1][2]. Evolutionary Programming(EP)is generallyusedto optimize real-valued continuous functions. EP uses selection and mutation operators; it does not use the recombination operator. The focus is on phenotypic evaluation and not on genotypic evaluation[3][4].

Particle Swarm Optimization (PSO) is a very important computational method. This was introduced by Kennedy and Eberhart [5] in 1995. This was introduced as a new heuristic method influenced by the social behavior of bird flocks and fish schools. This method optimizes a problem, which has the population of candidate solutions. The particles move in the search space according to simple mathematical formulae and their movement is influenced by its local best and guided towards the global best. PSO can optimize the problem which has very little no prior information; hence it is meta-heuristic in nature. PSO concept examines how changes in the paradigm affect the number of iterations required to meet an error criterion and the frequency with which models cycle interminably around a non-global optimum solution [4].

II. MATERIAL AND METHODS

When the sound or acoustic wave hits the eardrum it vibrates. These vibrations are passedto the cochlea through three small bones.The cochlea is a helical structure surrounded by bones and it is filled with fluid. The cochlea is divided into three chambers the scala vestibule, the scala media and the scala tympani by two membranes Reissener's membrane and the basilar membrane. The response of the basilar membrane is a wave which begins at the cochlear base which moves towards the apex. In the implantation the base to apex dimension is calculated and the highest frequencies causing maximum displacement near the base and the lowest frequencies causing maximum displacement towards teapex[7]-[8]. For the cochlear implant there are many clinical parameters, as angle of insertion, place of insertion, length of corti, position of cochlea tunnels etc. play a very important role. The various mechanical and clinical parameters are to be matched [9].

Particle Swarm Optimization

The PSO algorithm proposed by Kennedy and Everhart is insensitive to scaling of design variables and free from the condition of differentiability and requires very few parameters. Hence, it is very efficient search algorithm.Figure1 represents the flow chart for the Particle Swarm Optimization Algorithm

x_k^i----- The Position of the Particle
v_k^i----- The Velocity of the Particle
p_k^i ----- Personal Best Individual Particle Position
p_k^g ----- Global Best Swarm Position
c_1,c_2----- Cognitive and social parameters
r_1,r_2----- Random Numbers between 0 and 1
Position of the individual particles is calculated as follows:
$x_{k+1}^i = x_k^i + v_{k+1}^i$with the velocity calculated as follows:
$v_{k+1}^i = v_k^i + c_1 r_1 (p_k^i - x_k^i) + c_2 r_2 (p_k^g - x_k^i)$

Algorithm:
Step1. Initialize
(i) Set the initial values of Constants Kmax, c_1,c_2.
(ii) Initialize the particle positions $x_0^i \in D\ in\ IR^n$ for i=1....p;
(iii) Randomly initialize particle velocities $0 \leq v_0^i \leq v_0^{max}$ for i=1….p
(iv) Set k=1
Step2.Optimize
(i) Evaluate function value f_k^i using design space coordinates x_k^i
(ii) If $f_k^i \leq f_{best}^i\ then\ f_{best}^i = f_k^i, p_k^i = x_k^i$
(iii) If$f_k^i \leq f_{best}^g\ then\ f_{best}^g = f_k^i, p_k^g = x_k^i$
(iv) If Stopping Condition is satisfied then go to Step 3
(v) Update all particle velocities v_k^i for i=1….p
(vi) Update all particle positions x_k^i for i-1…..p
(vii)Increment k.
(viii) Go to Step 2(i).
Step3.Stop

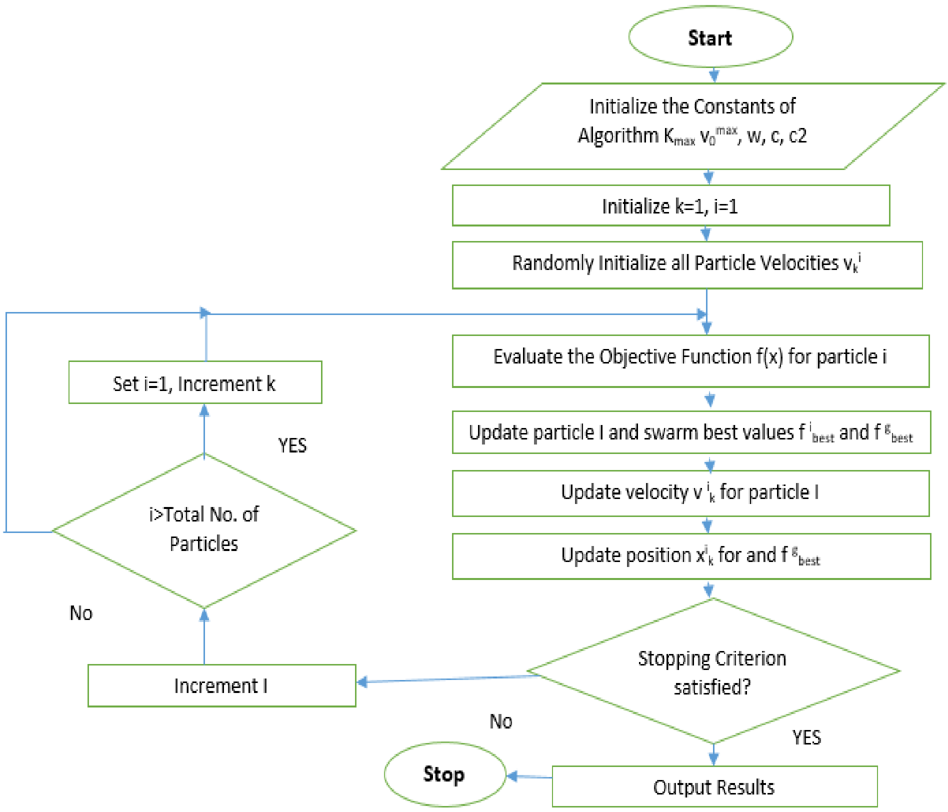

Figure1: Flow Chart for the Particle Swarm Optimization Algorithm

Fitness Function:
In the present study, we have used Greenwood equation as the fitness function [10]. Twenty two electrodes have been used for stimulation. The frequency position function

$f = A.10^{ax} - k$ implies

$$x = \frac{\log_{10}\frac{f+k}{A}}{a}$$

has been used to calculate positions for various electrodes for cochlea stimulation. Here,'f' showsthe frequency in Hz unit, while 'x' describes the length ratio of base from 0 to 1. 'A' and 'a'are constant and their values are 156.4 and 2.1 respectively. The selection of electrodes is thesame as that of N-*M* model[7]. In this study, six electrodes are selected from twenty two channelelectrodes and only these six electrodes, which have the highest amplitude, are analyzedusing the wavelet packet transform.
Taking, A=165.4;a=2.1;x= varies from 0 to 1;k=0.88, we have
f =165.4*power(10,(2.1*x))- 0.88
Bychanging different target levels of frequency we can get different values for x, which is returning the approximate value for the whole length of corti.At what location of corti, which frequency level electrode must be attached, this has been optimized using particle swarm optimization.

III. RESULTS AND DISCUSSION

In the present study, we have optimized the frequency levels and the length of corti simultaneously by using particle swarm optimization technique and greenwood equation has been used to determine the location of electrode for particular frequency electrode.The frequency is triggered using appropriate level at the mapping time of the patient.

After going through the results we can conclude particle swarm optimization is really feasible approach to find the location and frequency simultaneously. The optimization of proper place may guide the implantation surgeon in appropriate manner to put the electrode of given frequency at particular place Ifthe appropriate frequencies are selected at the total length of corti, only than it can stimulate the brain of the implantee, so that he/she may respond properly. The distribution of frequencies over the whole length of filament on which the various electrodes are located should cover all audible frequency range or in other words we can say that all audible frequencies are to be mapped with the help of the electrodes so that the patient may become able to hear all type of sounds properly. In table 1, the numerical value between frequency and the length of corti using PSOhas been mentioned.

Table 1: Representing the relation between frequency and the length of corti using PSO

S.No.	Frequency in Hz	x Value (Using Greenwood equation)	X Value (Using PSO)
1	200	0.040191	0.0477
2	400	0.183085	0.1002
3	600	0.266787	0.1960
4	800	0.326206	0.2682
5	1000	0.372308	0.3549
6	1200	0.409983	0.4147
7	1400	0.441841	0.4226
8	1600	0.469440	0.4627
9	1800	0.493785	0.4884
10	2000	0.515565	0.4958
11	2200	0.535267	0.5237
12	2400	0.553255	0.5320
13	2600	0.569802	0.5558
14	2800	0.585123	0.5598
15	3000	0.599387	0.5614
16	3200	0.612730	0.5731
17	3400	0.625265	0.6038
18	3600	0.637082	0.6370

19	3800	0.648261	0.6401
20	4000	0.658867	0.6588
21	4200	0.668955	0.6604
22	4400	0.678573	0.6719
23	4600	0.687764	0.6725
24	4800	0.696564	0.6877
25	5000	0.705005	0.6887
26	5200	0.713115	0.6970
27	5400	0.720919	0.7141
28	5600	0.728438	0.7176
29	5800	0.735694	0.7265
30	6000	0.742704	0.7397
31	6200	0.749485	0.7470
32	6400	0.756050	0.7574
33	6600	0.762413	0.7619
34	6800	0.768586	0.7644
35	7000	0.774580	0.7654
36	7200	0.780405	0.7657
37	7400	0.786070	0.7788
38	7600	0.791585	0.7814
39	7800	0.796956	0.7849
40	8000	0.802192	0.7864
41	8200	0.807298	0.8022
42	8400	0.812281	0.8093
43	9400	0.835540	0.8372
44	10400	0.856445	0.8555
45	11200	0.871770	0.8716
46	11600	0.879026	0.8790
47	12000	0.886037	0.8555
48	13000	0.902589	0.9013
49	14000	0.917914	0.9163
50	15000	0.932182	0.9264
51	16000	0.945528	0.9436
52	17000	0.958065	0.9647
53	18000	0.969885	0.9701
54	19000	0.981066	0.9853
55	20000	0.991673	0.9940

The frequencies are varying from 0 to 20000 Hz. and the length of corti is varying from 0 to 1unit. The x values have been obtained by using standard Greenwood equation and particle swarm optimization both. The values xobtained by PSO are reflecting very closer values as obtained by Greenwood equation x values.But using PSO we are providing the actual location of corti for the particular patient’s anatomy.Figure 2 has been obtained by using greenwood equation, while Figure 3 has been drawn by using particle swarm optimization considering varying human anatomy for different patients.

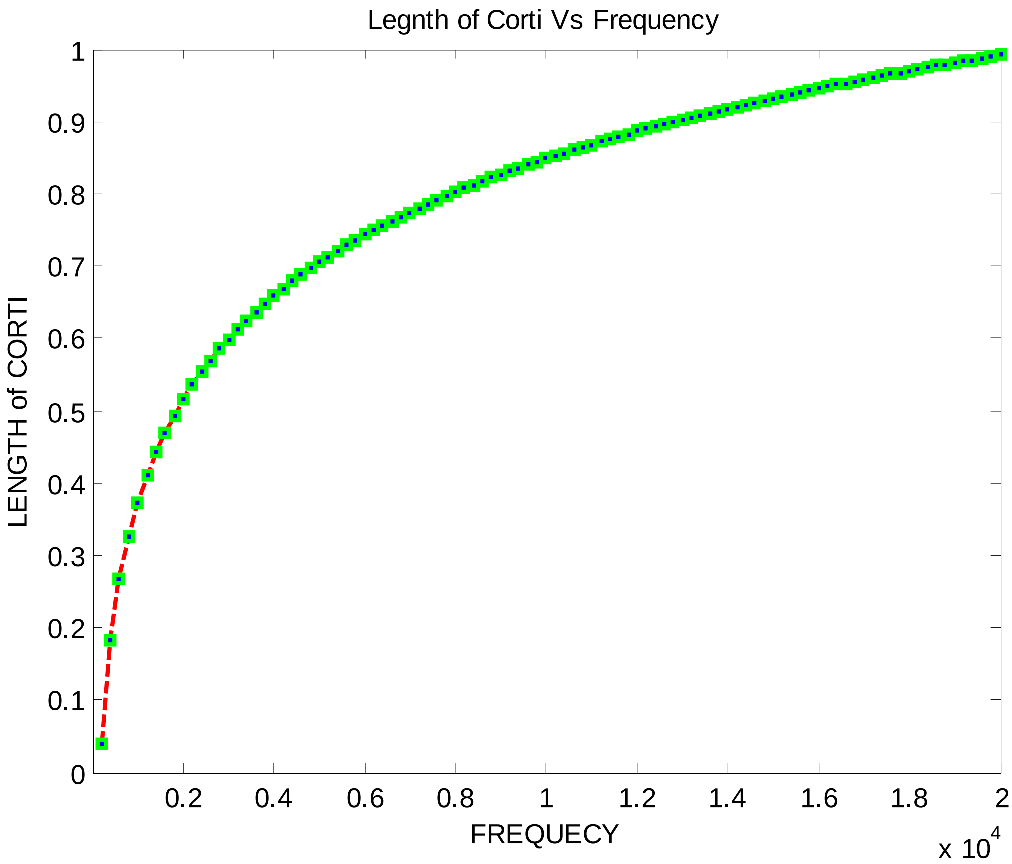

Figure 2: Frequency Vs. Length of Cortiusing Greenwood equation

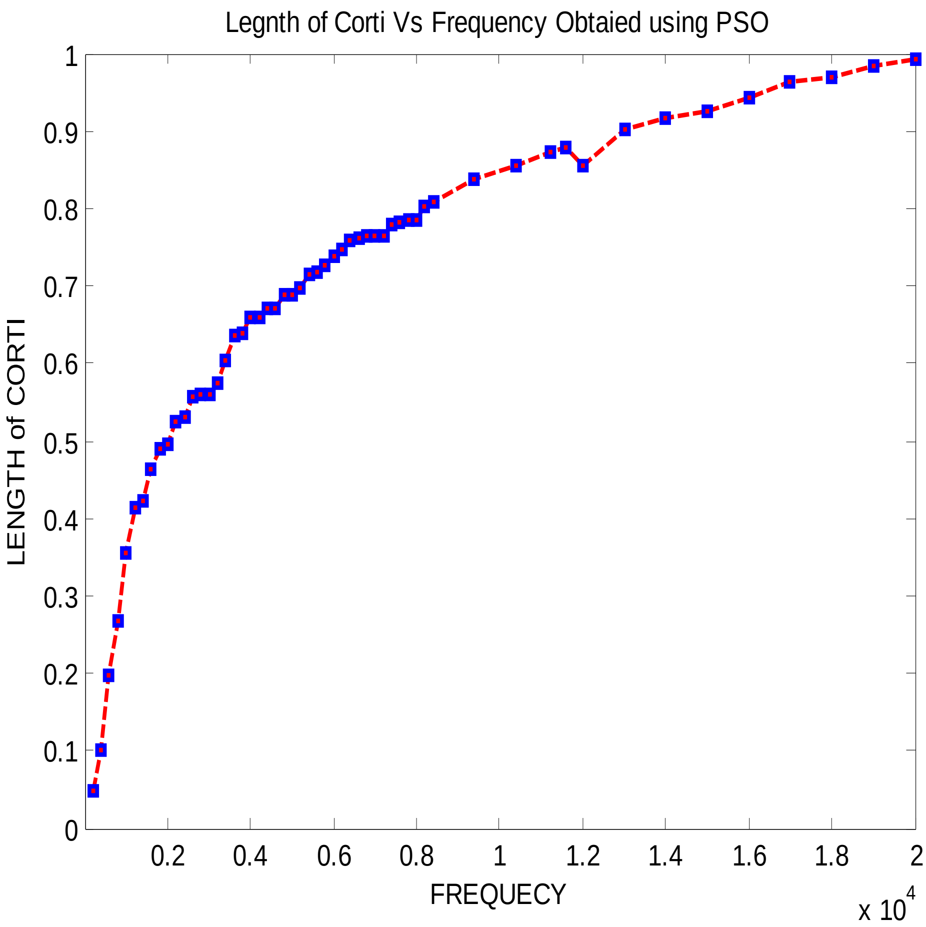

Figure 3: Frequency Vs. Length of Corti using Particle Swarm Optimization

IV. CONCLUSION

From Figure 2 and Figure 3, it may be concluded that the electrodes having lower frequencies are implanted at the initial position of Corti or at inner position of cochlea while higher frequencies are implanted at outer position of cochlea. Length of Corti obtained by using Greenwood equation and using Particle Swarm Optimization are very much identical, but if the anatomy of a particular patient varies then particle swarm optimization is the best way as constantly we are matching the results with the previous case history of the patients, as we are considering local best and global best.

REFERENCES

[1]. **P.Saxena**, "A Note on Blue Hearing System to Develop Speech in Deaf and Mute People", *Recent Research in Science andTechnology*, 2010, 2(9): 04-07.

[2]. **Katherie R. Heshall, Colette M.Mckay**, Optimizing Electrode and Filter Selection in Cochlear Implant Speech Processor Maps, *J Am AcadAudiol*, 12:478-489,2001.

[3]. **Holland**, **J.**, Adaption in Natural & Artificial Systems, *University of Michigan, USA*,The MIT Press, 1975.

[4]. **Fogel,** Evolutionary Programming in Perspective: The Top-down View, Computational Intelligence: Imitating Life , *IEEE Press*, New Jersey, USA, 1994.

[5]. **J. Kennedy, R. Eberhart**, "Particle swarm optimization", *Proceedings of the IEEE International Conference on Neural Network*, 1995, pp. 1942–1948.

[6]. **R.C. Eberhart, Y..Shi**, "Particle swarm optimization: developments, applications and resources, evolutionary computation", Proceedings *of the 2001 Congress on Evolutionary Computation*, 2001, pp. 81–86.

[7]. **Goury Olivier, Yan Nguyen, Torres Renato, Dequigt and ChristiaDuriez**, "Numerical Simulation of Cochlear-Implant Surgery: Towards Patient's specific Planning", *Conference Paper in Lecture Notes in Computer Science*–October 2016.

[8]. **Tierney J., Zissman M.A., Eddington D.K., "**Digital Signal Processing Applications in Cochlear Implant Research", *The Lincoln Laboratory Journal*, 1994, Volume 7, Number 1, 31-.

[9]. **Goury Olivier, Torres Renato**, "Numerical Simulation of Cochlear-/Implant Surgery:Towards Patient specific planning/", *Conference Paper in Computer Science*, October 2016.

[10]. **D. D Greenwood**., "A cochlear frequency-position functions for several species-29 yearslater"*J. Acoust. Soc. Am.*, 1990, vol. 87, no. 6, pp. 2593-2605.