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Using Genetic Programming for Estimating Telecommunication Towers Natural Frequency

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Abstract*: In artificial intelligence, genetic programming is a technique whereby computer programs are encoded as a set of genes. In this research, using GP and according to calculated parameters in SAP2000 software including base cross section, height of floors, truss inner and outer radius and guy inner and outer radius for 100 towers and after training of them, some models were provided and were compared with other 100 analyzed model in SAP2000 software and their error percent were provided for each model.

Keywords— natural frequency, Genetic Programming, telecommunication towers

I. Introduction

Providing a program using usual programming techniques to answer to problems having too many variables as input or output is impractical because considering all these variables and their effects to each other is impossible. So using Genetic Programming (GP), providing a software to solve this problem is possible. Traditional programming methods are such that having error in the input information has effect on all of computations but in GP the program has fault- tolerance capability.

Genetic programming (GP) is a collection of evolutionary computation techniques that allow computers to solve problems automatically. Genetic programming (GP) is an automated method for creating a working computer program from a high-level problem statement of a problem (Venkat Narayana Rao and madiraju, 2010). The basic purpose of genetic programming (GP) is optimization. Since optimization problems arise frequently, this makes GP quite useful for a great variety of tasks.GP is used in different scientific fields (Khosravian and Khosravi, 2009). Some of GP applications in the field of civil engineering are optimization, analysis, designing, prediction of deflection and weight of structures, analysis and design of connections, prediction of the results for telecommunication and soil tests and also using GP in the graph theories.

Telecommunication towers are important components of basic infrastructure of communication systems and thus preserving them in events of natural disasters such as sever earthquakes is of high priority. The structure engineer faces the challenging job of designing and constructing telecommunication towers to support antenna loads, platform as well as steel ladder loads in open weather with high degree of reliability (Rajasekharan and Vijaya, 2014). With advances in telecommunication industry, the use of telecommunication towers is rapidly increasing (Silve et al, 2007).

Telecommunication towers are among the few steel structures that little attention has been paid to their seismic behavior in existing design code (kumarci and B. Dehkordi, 2011). With advances in the telecommunication industry, the use of telecommunication towers is rapidly increasing (Godrati et al., 2007). Calculation of structures frequency and restricted them by determined values (or maximize) has two results: decreasing of structure frequency amplitude and prevention of resonance in structure dynamic response (kumarci et al., 2008). In resonation, the frequency of loading is equal to natural frequency of resonation. So, if the structure dimension or its shape change, resonation range and structure deformation will change. To sum up, tension will decrease and it leads to security in structures (Chuenmei, 1984).

II. Telecommunication towers

In this research, the towers are made of aluminum alloy pipes. Outer and inner radius for trusses and guyed are 0.032, 0.03, 0.022 and 0.014, respectively. Also, Young's modulus is 7×10^{10} Pa and Poisson's ratio is 0.29 and no pressure is applied on the tower. For instance, we considered a telecommunication tower and analyzed it at first ten mode shapes. The considered tower is made in four floors which the height of each floor and base cross section are 6m and $4\times4m^2$, respectively. The four base points are fixed on ground (figure1).

Modal analysis has been applied for considered tower and the first ten modes are provided in figure 2.

Considering desired frequency, the follows should be considered in optimization:

1) Decreasing of used pieces volume which is cause of decreasing of mass and inertia.

2) Increasing of structure flexibility which is cause of decreasing of earthquake force.

3) Decreasing of seismic forces using suitable formability.

4) Using suitable designing method.

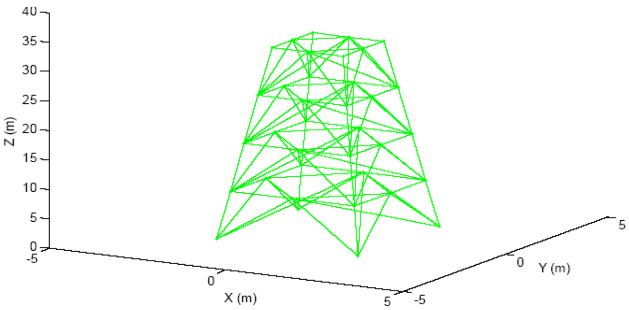

Fig 1. Unformed geometry of the tower.

First of all, 100 telecommunication towers with different dimensions were chosen as input. Seven parameters (base cross section, height of floors, inner and outer radius in truss, inner and outer radius in braces, Poisson, s ratio, Young's modulus and density) were consider for each of towers, first and second parameters change by geometric dimensions. These changes are varying in the base cross section (2 × 2 to 6 × 6 m) and height of floor (5 to 14 m). Third and fourth parameters, inner and outer radius in truss and braces, are fixed in all of towers. Regard to quality of telecommunication tower, the fifth, sixth and seventh parameters were used. These parameters were fixed our research.

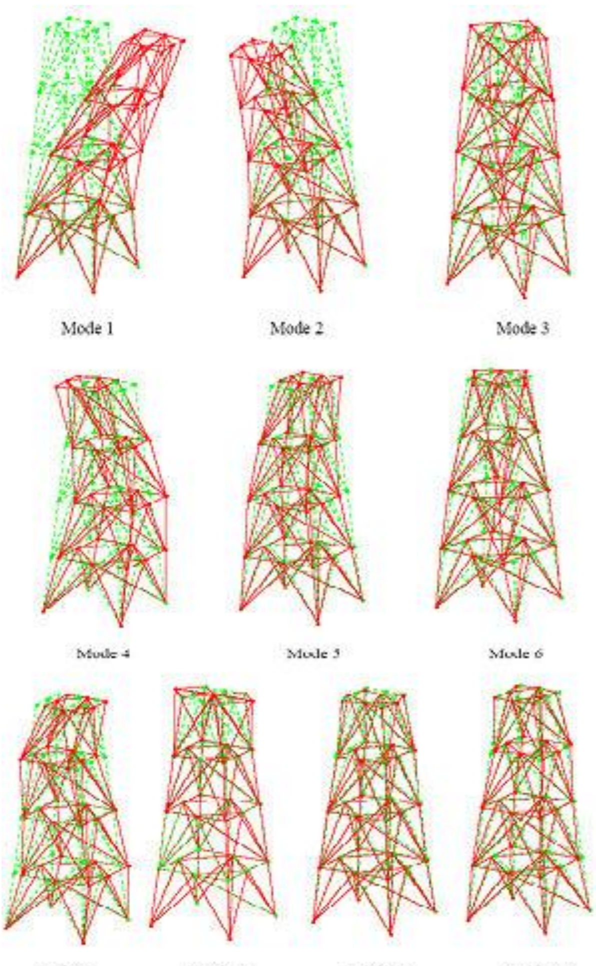

Figure 2: First ten modes of tower

II. Genetic Programming configuration

To models providing using GP, it is necessary to have suitable setting for GP including primary setting and determination of mathematical operators.

Primary setting

In this section, the follow factors should be considered in genetic programing:

1. Data value and number of variables (table 1)
2. General settings include number of chromosomes and gens, size of head, tail, the place of division and gen linking function (table 2)
3. Fitness function (table 3)
4. Genetic operators (table 4)
5. Numerical constants (table 5)

Data	
Independent Variables:	6
Training Samples:	100
Testing Samples:	

Table 1. Data

Settings	
General	
Chromosomes:	30
Genes:	3
Head Size:	8
Tail Size:	25
Dc Size:	25
Gene Size:	58
Linking Function:	Addition

Table 2. General setting

Fitness Function	
Error Type:	RRSE
Precision:	--
Selection Range:	--

Table 3. Fitness function

Genetic Operators	
Mutation Rate:	0.044
Inversion Rate:	0.1
IS Transposition Rate:	0.1
RIS Transposition Rate:	0.1
One-Point Recombination Rate:	0.3
Two-Point Recombination Rate:	0.3
Gene Recombination Rate:	0.1
Gene Transposition Rate:	0.1

Table4. Genetic operators

Numerical Constants	
Constants per Gene:	2
Data Type:	Floating-Point
Lower Bound:	-10
Upper Bound:	10
RNC Mutation:	0.01
Dc Mutation:	0.044
Dc Inversion:	0.1
Dc IS Transposition:	0.1

Table 5. . Numerical constants

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III. Comparing telecommunication tower natural frequency in SAP2000 and GP

In this part, 100 telecommunication tower samples have been analyzed and according to change of two parameters including cross section and the height of tower, the results have been provided in table 6 which are considered as primary population for GP model. Finally the best model will be chosen.

No.	base cross section	Floor height	Number of floors	tower height	Tower frequency at the first mode using SAP2000	Tower frequency at the first mode using GP	Error percent
1	2*2	5	4	20	3/05	3/599	18/00
2	3*3	5	4	20	3/55	3/976	12/00
3	4*4	5	4	20	4/05	4/779	18/00
4	5*5	5	4	20	4/45	4/806	8/00
5	6*6	5	4	20	4/85	5/5775	15/00
6	2*2	6	4	24	2/66	3/1122	17/00
7	3*3	6	4	24	3/16	3/4128	8/00
8	4*4	6	4	24	3/66	4/0992	12/00
9	5*5	6	4	24	4/26	4/8138	13/00
10	6*6	6	4	24	4/66	4/9862	7/00
11	2*2	7	4	28	3/16	3/3812	7/00
12	3*3	7	4	28	3/46	3/7714	9/00
13	4*4	7	4	28	3/76	4/3616	16/00
14	5*5	7	4	28	4/26	4/686	10/00
15	6*6	7	4	28	4/76	5/3788	13/00
16	2*2	8	4	32	3/08	3/542	15/00
17	3*3	8	4	32	3/68	4/232	15/00
18	4*4	8	4	32	3/98	4/6566	17/00
19	5*5	8	4	32	4/48	5/152	15/00
20	6*6	8	4	32	4/78	5/3058	11/00
21	2*2	9	4	36	3/19	3/6685	15/00
22	3*3	9	4	36	3/49	3/8041	9/00
23	4*4	9	4	36	3/89	4/5513	17/00
24	5*5	9	4	36	4/29	4/9764	16/00
25	6*6	9	4	36	4/59	5/3703	17/00
26	2*2	10	4	40	3/77	4/2601	13/00
27	3*3	10	4	40	4/07	4/477	10/00
28	4*4	10	4	40	4/47	5/1405	15/00
29	5*5	10	4	40	4/97	5/5167	11/00
30	6*6	10	4	40	5/57	5/9599	7/00
31	2*2	11	4	44	3/33	3/7629	13/00
32	3*3	11	4	44	3/63	3/993	10/00
33	4*4	11	4	44	4/23	4/5261	7/00
34	5*5	11	4	44	4/83	5/5545	15/00
35	6*6	11	4	44	5/33	5/9163	11/00
36	2*2	12	4	48	3/69	4/1697	13/00
37	3*3	12	4	48	4/29	4/8477	13/00
38	4*4	12	4	48	4/59	5/1867	13/00
39	5*5	12	4	48	4/99	5/8882	18/00
40	6*6	12	4	48	5/49	6/1488	12/00
41	2*2	13	4	52	3/07	3/5305	15/00
42	3*3	13	4	52	3/67	4/0737	11/00
43	4*4	13	4	52	4/17	4/8789	17/00
44	5*5	13	4	52	4/67	5/0903	9/00
45	6*6	13	4	52	5/17	5/5836	8/00
46	2*2	14	4	56	3/77	4/0716	8/00
47	3*3	14	4	56	4/27	4/697	10/00
48	4*4	14	4	56	4/87	5/3083	9/00
49	5*5	14	4	56	5/47	6/3999	17/00
50	6*6	14	4	56	5/77	6/4624	12/00
51	2*2	5	5	25	2/72	3/0736	13/00
52	3*3	5	5	25	3/22	3/7674	17/00
53	4*4	5	5	25	3/52	3/9776	13/00
54	5*5	5	5	25	4/12	4/5732	11/00

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55	6*6	5	5	25	4/52	4/972	10/00
56	2*2	6	5	30	3/33	3/8961	17/00
57	3*3	6	5	30	3/83	4/3662	14/00
58	4*4	6	5	30	4/43	4/873	10/00
59	5*5	6	5	30	5/03	5/7845	15/00
60	6*6	6	5	30	5/63	6/0241	7/00
61	2*2	7	5	35	2/70	3/051	13/00
62	3*3	7	5	35	3/20	3/52	10/00
63	4*4	7	5	35	3/60	4/14	15/00
64	5*5	7	5	35	3/90	4/485	15/00
65	6*6	7	5	35	4/20	4/914	17/00
66	2*2	8	5	40	2/99	3/4983	17/00
67	3*3	8	5	40	3/49	4/1182	18/00
68	4*4	8	5	40	3/99	4/6284	16/00
69	5*5	8	5	40	4/49	5/2084	16/00
70	6*6	8	5	40	4/89	5/3301	9/00
71	2*2	9	5	45	3/87	4/5666	18/00
72	3*3	9	5	45	4/37	4/9381	13/00
73	4*4	9	5	45	4/67	5/0436	8/00
74	5*5	9	5	45	5/27	6/1659	17/00
75	6*6	9	5	45	5/87	6/7505	15/00
76	2*2	10	5	50	3/05	3/3245	9/00
77	3*3	10	5	50	3/65	4/1245	13/00
78	4*4	10	5	50	4/05	4/536	12/00
79	5*5	10	5	50	4/35	4/872	12/00
80	6*6	10	5	50	4/85	5/2865	9/00
81	2*2	11	5	55	4/07	4/3956	8/00
82	3*3	11	5	55	4/67	4/9969	7/00
83	4*4	11	5	55	5/07	5/6277	11/00
84	5*5	11	5	55	5/67	6/5205	15/00
85	6*6	11	5	55	5/97	7/0446	18/00
86	2*2	12	5	60	3/41	3/7169	9/00
87	3*3	12	5	60	4/01	4/6115	15/00
88	4*4	12	5	60	4/61	5/3015	15/00
89	5*5	12	5	60	5/21	5/8873	13/00
90	6*6	12	5	60	5/61	6/2832	12/00
91	2*2	13	5	65	4/30	4/73	10/00
92	3*3	13	5	65	4/90	5/635	15/00
93	4*4	13	5	65	5/40	6/156	14/00
94	5*5	13	5	65	5/70	6/669	17/00
95	6*6	13	5	65	6/30	7/245	15/00
96	2*2	14	5	70	3/88	4/5396	17/00
97	3*3	14	5	70	4/38	4/8618	11/00
98	4*4	14	5	70	4/98	5/8266	17/00
99	5*5	14	5	70	5/48	6/302	15/00
100	6*6	14	5	70	6/08	6/5664	8/00

Table 6: Calculation of telecommunication tower natural frequency using SAP2000 and GP

V. Conclusion

In this study an integrated model has investigated the use of Genetic Programming to estimation of telecommunication tower natural frequency. The results of analysis of natural frequency using SAP2000 software and GP model were analyzed and compared. According to the results, using GP complexity of the model could turn development time long. Regard to mentioned points and GP as a developed calculation method to complex behavior modeling, GP model is better than other modeling methods GP model has error percent equal 12.8 so it can calculate telecommunication tower natural frequency in less time than SAP2000 software. The results are depicted in figures 3 and 4.

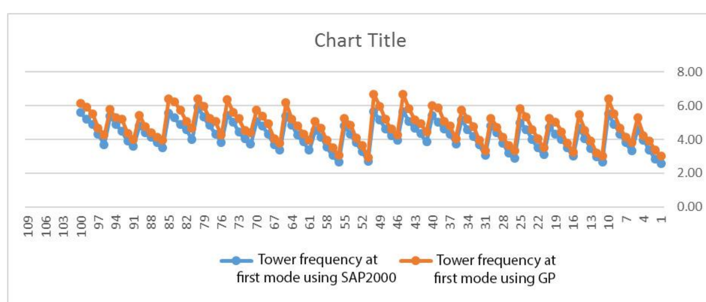

Fig 3.Comparing natural frequency using SAP2000 and GP

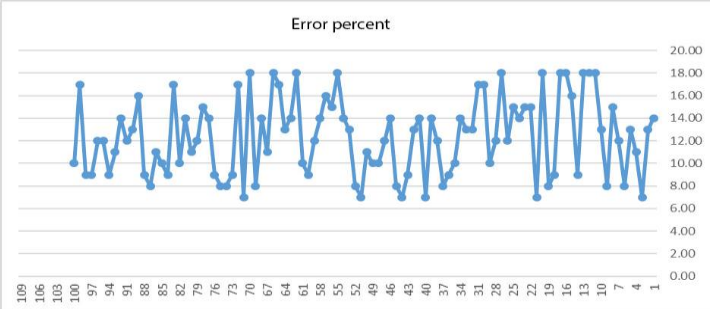

Fig 4. Estimation of error percent using GP in 100 telecommunication tower samples

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