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Application of routine calibration of real water supply network with adjustment of demand roughness parameters driven by applied pressure real network of Brazil

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Abstract

The calibration of water distribution networks is one way to perform such procedures in hydraulic models, but several are the difficulties encountered in calibrating a real network. This work proposes the improvement of modules of the calibration method proposed by Silva (2003), where using the genetic algorithm (GA) search tool, the author calibrates a real water distribution network of a Brazilian city, adjusting parameters mainly from roughness and coefficient of leakage. The enhancement of GA is the introduction of a new decision variable, the nodal demand, which assigns demand values to nodes according to the pressure-driven demand model of Tucciarelli, Criminisi and Termini (1999). The tests of the GAs implemented are tested for this real water distribution network presented by Silva (2003). The effect of the improvement on the calibration results was significant for the network, but the need for more in-depth studies, which are of course required for the application of new algorithms in real-scale networks.

Keywords: water distribution network Structure, Genetic Algorithms, calibration

1. Introduction

According to Walski (1986), from a simplistic point of view, the calibration can be divided into two stages: (1) a comparison of the pressures and flows predicted in the hydraulic simulation model with the pressures and flows observed with the system working within the operating conditions; (2)

adjustment of input data in the hydraulic model in order to increase the consistency of expected and observed results.

Some recent calibration studies of water distribution networks such as Silva (2003) Borges et al. (2008), Ganem et al. (2012), Salvino et al. (2012), Nasirian, Maghrebi and Yazdani (2013), Silva et al. (2013) and Rocha (2013), Goulart (2015) and Santos (2016).

Another aspect also studied are hydraulic pressure-driven simulation models (MSHDP), adopting different relations between demand and the respective service pressures. The following authors are noteworthy in this line of research: Fujiwara and Li (1998) and , Tucciarelli, Criminisi and Termini (1999). Tucciarelli, Criminisi and Termini (1999), applied the demand model in the calibration process of a water distribution network, proposing a model of pressure x sinusoidal demand.

2. Material and methods

For a study was selected a real network of the interior of the state of São Paulo Brazil composed of 58 nodes and 83 stretches. The Table 1 shows the network data, including nodes, expected demand, diameter and roughness.

NODE	ELEVATION (m)	DEMAND (L/s)	NODE	NODE	LENGTH (m)	DIAMETER (mm)	ROUGHNESS (mm)
1	843,00	0,027	1	2	30	50	0,06
2	841,20	0,079	2	3	65	50	0,06
3	836,50	0,092	2	7	106	50	0,06
4	831,90	0,074	2	8	106	50	0,06
5	855,60	0,027	3	9	92	50	0,06
6	854,50	0,048	3	24	292	50	0,06
7	853,10	0,048	3	57	30	50	0,06
8	853,70	0,122	4	11	96	50	0,06
9	850,10	0,122	4	12	150	50	0,06
10	847,00	0,095	4	57	44	50	0,06
11	845,40	0,177	5	6	30	50	0,06
12	828,00	0,082	6	7	22	50	0,06
13	855,80	0,021	6	13	68	50	0,06
14	845,30	0,153	7	23	198	50	0,06
15	826,10	0,098	8	9	56	50	0,06
16	854,50	0,039	8	23	198	50	0,06
17	845,90	0,164	9	24	200	50	0,06
18	829,50	0,179	10	11	34	50	0,06
19	856,40	0,083	11	12	122	50	0,06
20	853,80	0,066	11	14	74	50	0,06
21	853,80	0,042	13	16	64	50	0,06
22	854,00	0,025	13	19	166	50	0,06
23	851,30	0,116	14	15	156	50	0,06
24	848,20	0,146	14	17	68	50	0,06
25	846,20	0,141	16	21	70	50	0,06
26	836,00	0,247	16	22	20	50	0,06
27	829,70	0,095	17	18	214	50	0,06
28	856,00	0,000	17	25	60	50	0,06
29	854,70	0,016	18	27	244	50	0,06
30	849,60	0,059	19	20	90	50	0,06
31	842,20	0,062	19	21	90	100	0,06
32	842,20	0,077	19	28	122	100	0,06
33	835,60	0,206	19	54	110	50	0,06
34	830,10	0,104	21	22	54	50	0,06
35	825,70	0,037	21	23	60	50	0,06
36	840,10	0,088	21	55	84	50	0,50
37	836,20	0,095	23	24	66	50	0,06
38	837,30	0,131	24	25	70	50	0,06
39	831,00	0,202	25	26	222	50	0,06
40	824,50	0,123	25	31	82	50	0,06
41	823,00	0,065	26	27	225	50	0,06
42	823,30	0,029	27	35	90	50	0,06
43	830,60	0,084	28	29	28	150	0,06
44	828,00	0,114	28	56	22	150	0,06
45	820,00	0,179	29	32	325	75	0,50
46	821,20	0,208	29	36	172	50	0,06
47	824,20	0,208	30	36	68	50	0,06
48	821,60	0,216	31	33	228	50	0,06
49	825,40	0,297	31	38	78	50	0,06
50	824,10	0,138	31	55	195	50	0,50
51	816,20	0,138	32	38	88	75	0,06
52	815,00	0,050	33	34	144	50	0,06
53	818,70	0,118	33	39	70	50	0,06
54	855,90	0,066	34	35	142	50	0,06
55	849,60	0,104	34	41	56	50	0,06
56	855,50	-6,386	35	41	170	50	0,06

NODE	ELEVATION (m)	DEMAND (L/s)	NODE	NODE	LENGHT (m)	DIAMETER (mm)	ROUGHNESS (mm)
57	833,30	0,040	36	37	102	50	0,06
58	828,30	0,522	36	42	126	50	0,06
			37	38	85	50	0,06
			37	43	125	50	0,06
			38	39	234	50	0,50
			38	43	80	50	0,50
			39	40	92	50	0,06
			39	44	90	50	0,06
			40	41	82	50	0,06
			40	51	260	50	0,06
			42	45	192	50	0,06
			42	46	116	50	0,06
			43	44	204	50	0,06
			43	47	70	50	0,06
			43	49	170	50	0,06
			44	50	80	50	0,06
			45	46	34	50	0,06
			45	52	190	50	0,06
			46	47	20	50	0,06
			47	48	108	50	0,06
			49	53	140	50	0,06
			49	58	85	50	0,06
			50	51	62	50	0,06
			50	58	50	50	0,06
			51	53	285	50	0,06
			54	55	138	50	0,50
			54	56	28	75	0,06

Table 1: Information real network study (continuation) (Silva, 2003 and Goulart, 2015)

After the introduction of the Tucciarelli, Criminisi and Termini (1999) pressure-driven mathematical model, another operator called TUCCIARELLI was developed, so the flowchart was altered as shown in Figure 1.

In general outlines of description, the GENERATOR routine the program performs different paths after the first generation. In the first generation are used rugosidades and demands generated by the program. But from the second generation onwards, despite the initial generation of rugosities and demands passing through the TUCCIARELLI operator, the demand changes according to the pressure criteria of the demand-driven demand model of Tucciarelli, Criminisi and Termini (1999). nodal pressure values obtained in the previous generation to which it is occurring.

After reading the data in the cycle following GENERATOR operator where randomly, also for both models implemented with the nodal demand, are generated an initial solution of roughness and an initial solution demands.

In SELECTION, the process of choosing the best solutions was done by the tournament method.

This evaluation is based on the pressure values obtained for the nodes and flow values at the entrance of the system. These values are the result of calculations with hydraulic each individual roughness and population in question demands for three patterns of use: maximum consumption (pattern 1), the average consumption (2 standard) and minimal consumption (Standard 3).

The hydraulic calculations of the problem are made possible by a sub-operator, called HYDRAULIC, where the friction losses (universal formula) and other parameters of interest are calculated. With the pressure and flow values resulting from each roughness and demand population, there is a value for the objective function, which compares the pressure and flow values observed in the field with the calculated pressure and flow values. The best solutions (roughness and demands), those that maximize the value of the objective function, are selected to exchange the genetic codes giving rise to new individuals, that is, new solutions to the problem.

The inverse problem of parameter determination by minimizing deviations between observed values and simulated pressure and flow values was expressed and maintained the same as that proposed by Silva (2003).

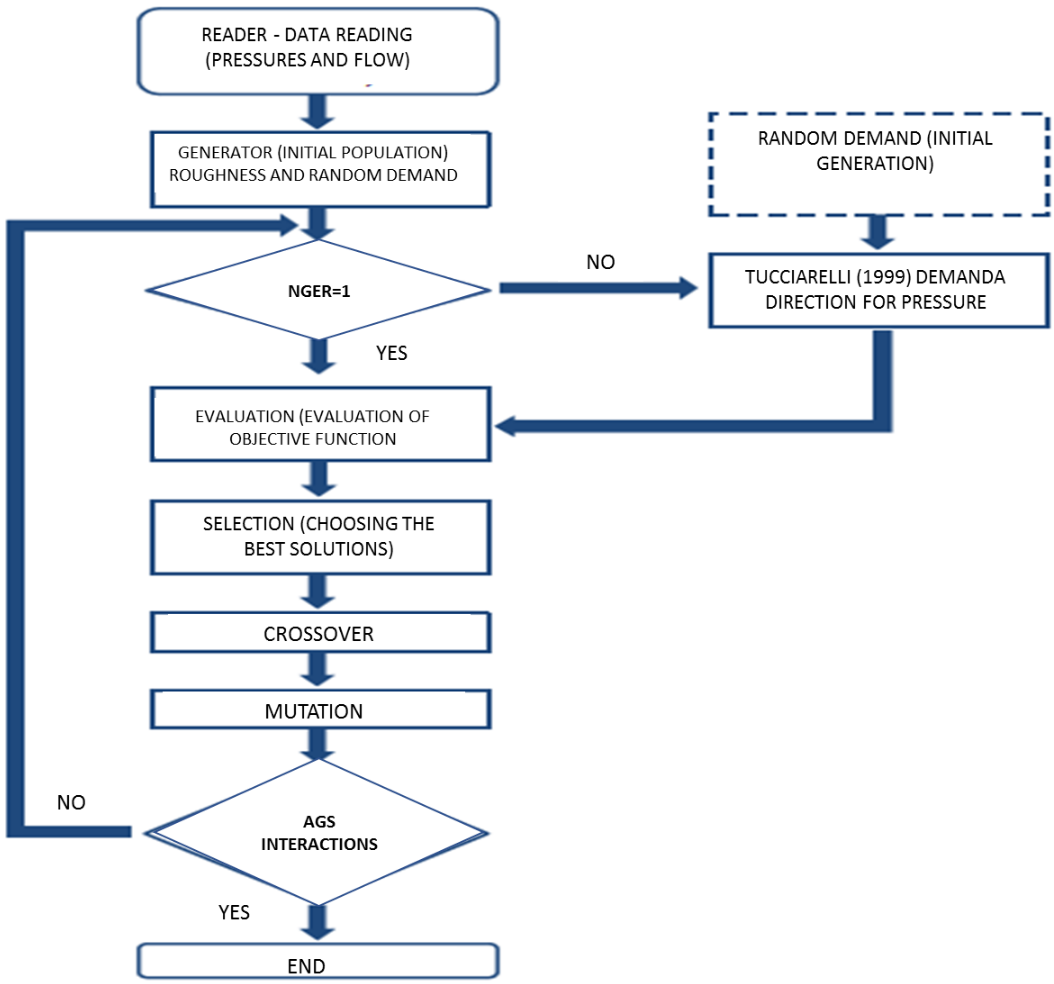

Figure 1: Flow diagram of GA implemented with operator TUCCIARELLI (Goulart, 2015)

3. Results

The figures 1,2 and 3 allows the comparison between the observed and simulated pressures for the three consumption patterns and for the distinct random populations resulting from the AG implemented with pressure directed demand. In general, the results between the observed values and the simulated values show a low difference between the values, in which the best results are related to the minimum consumption condition (standard 1).

The first standard represents lower, the standard 3 lower pressures and the 2 intermediate pressures standard.

The pressure values are shown in the ordinates. In the abscissa the nodes analyzed. The black bars represent the values measured from the work of Silva (2003) and the blue bars the values simulated from the flowchart of genetic algorithms and demand driven by pressure.

It is observed that the pattern of higher pressure presents the best adjustments of measured and simulated values.

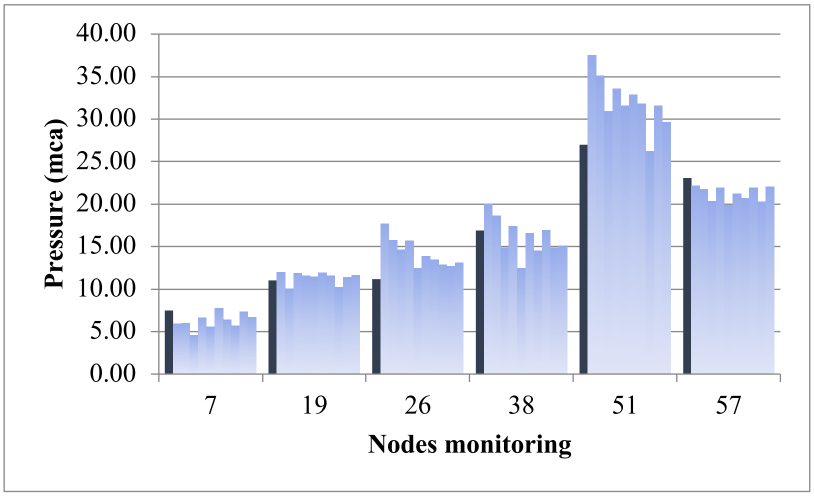

Figure 1: Simulated and observed pressures for all random populations, for the model implemented with pressure driven demand - consumption pattern 1

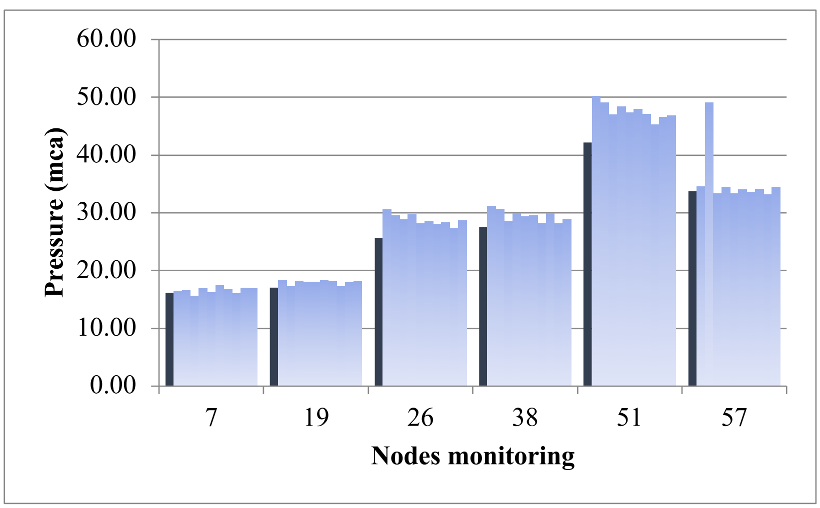

Figure 2: Simulated and observed pressures for all random populations, for the model implemented with pressure driven demand - consumption pattern 2

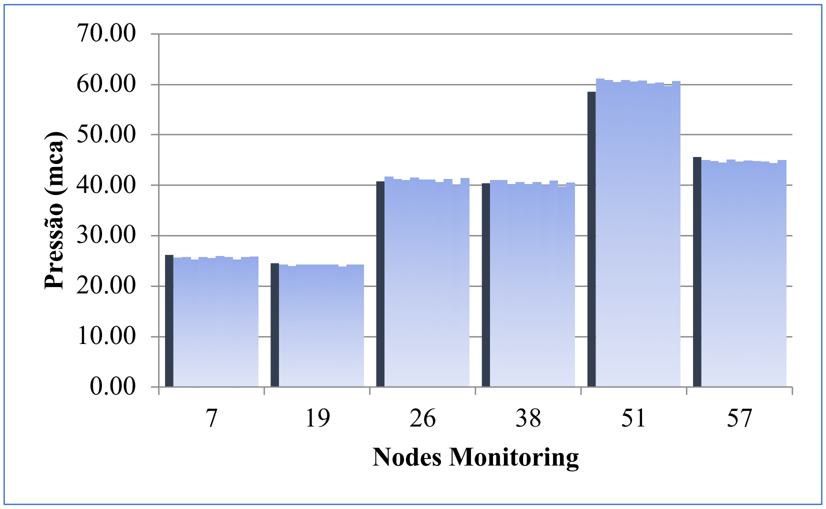

Figure 3 - Simulated and observed pressures for all random populations, for the model implemented with pressure driven demand - consumption pattern 3

4. Conclusions

The present work deals with a study of the improvement of computational GA for the calibration of water distribution networks. Based on the work of Silva (2003) that calibrated the roughness of the stretches and leakage parameters, the nodal flow variation based on the Tucciarelli, Criminisi and Termini (1999) model was considered, with demand driven as a decision variable of AG. The application of the GA was performed for a real network studied by Silva (2003), located in a Brazilian city consisting of 58 nodes and 83 stretches. With the results of this application the following conclusions can be verified:

-Values measured in the field were very close to the values calculated by the algorithm;

- The adjustment of roughness, leakage and pressure driven parameters made the adjustment very realistic.

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