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THE PARAMETRIC IDENTIFICATION OF A STATIONARY PROCESS

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Abstract: In the problems of identification it is supposed that the process has at least one measurable input size and at least one measurable output size. The identification of a process has three stages: the obtaining of a registration of process measurable sizes; the choice of a proper mathematical model for the process; the extract of the parameter values of the mathematical models from registered data. The parametric identification problem is an optimization problem, in which the best combination of values for the model parameters set is searched. In the paper is presented the parametric identification of a water flow process in a laboratory stand. The identification had the following dims: detailed understanding of how the stand works, finding a new illustrative experiment for the stand, the application of advanced techniques of automat control, and the development of a project of new stand, meant to allow a large variety of experiments.

Keywords: genetic algorithms, fitness function, flow control, level control

1. INTRODUCTION

The problems of parametric identification start from a set of experimental data $\{(y_k, u_k)\}$, k = 1, …, K and a mathematical model such as $y = g(u;x)$, where y is the output size, u is vector input size and x is the vector parameter of model. The objective function is minimum distance type. In most cases is chosen as objective function the distance introduced by the euclidian norm.

$$(1)\quad f(x) = \sqrt{\frac{1}{K}\sum_{k=1}^{K}\left(g(u_k;x) - y_k\right)^2}$$

or distance introduced by Manhattan norm

$$(2)\quad f(x) = \frac{1}{K}\sum_{k=1}^{K}\left|g(u_k;x) - y_k\right|$$

Frequently, the models are nonlinear functions and in this case the usage of optimization methods with derivative is difficult

Kristinsson [1992] make a survey on the techniques of parametric identification of a dynamic system with the help of genetic algorithms. Kristinsson uses the Simple Genetic Algorithm (SGA), with binary coded genes, just as it is described by Goldberg [1991]].

Maclay and Dorey [1995] present a case of parametric identification dynamic model of a vehicle with trailer. In this model it is considered the dynamics given by the vehicle mass, the trailer mass, constancy of elasticity couplings and action of the friction forces. A part of the parameter models were established by direct measurement, but nine parameters were determined by the minimization of the objective function with the help of the algorithm SGA (Simple Generic Algorithm). The results obtained with the genetic algorithm were compared with those obtained by the minimization of the objective function using the Levenberg-Marquartd method.

Bastien [1997] uses the genetic programming for the identification of the nonlinear static function which describes the operation furnace with gas. The genetic algorithm used was more complicated because it was asked to establish inclusively the structure of the nonlinear mathematical model used for identification. The data set used for identification consists of 220 pairs, where u_i entrances are the flow of gas and air and the output y_i is the concentration of CO_2 from burnt gas.

The work is organized in the following way: section two describes the experiment, section three presents the mathematical model of the process, section four presents the results of identification and the genetic algorithm used in identification, and section five shows the scheme a new level transducer.

2. DESCRIPTION OF THE EXPERIMENT

The following tests have been made on a laboratory stand used for the experimental regulatory tune of a level control loop or a flow control loop flow. The hydrodynamic scheme of the stand is presented in figure 1.

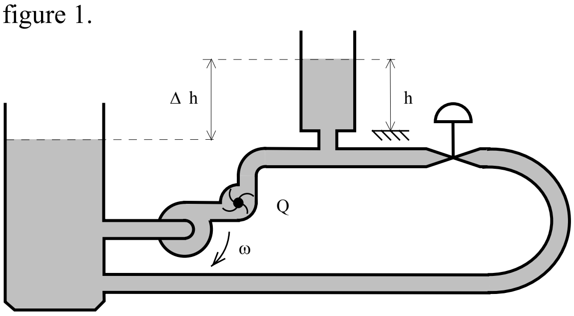

Fig. 1. The scheme of the laboratory stand.

The liquid is distillate water and chemically treated with a substance which prevents the growth of alga. The hydraulic circuit consists of: a reservoir for liquid storage; a centrifugal pump for liquid entrainment; a basin which has a capacitive transducer of level; a spherical manual sliding valve; a flow transducer with propeller.

The transducers adapters give an unified signal of 0 … 10V, and the amplifier which feeds the direct current motor, which operates the centrifugal pump, has also a commanding 0…10V signal. During the experiments the following shortcomings have been observed:

- the flow transducer, Q, is build with one propeller which moves into an optic gap. This transducer doesn’t work properly at low flow;
- the level transducer, h, is of capacitive type. Due to water evaporation the zero adjustment of the transducer of level needs to be done daily;
- the manual sliding valve, through which the charge control levels is modeled, isn't calibrated;

But, in spite of major nonlinearities that appear at slow flow, the stand may be used to in laboratory for experimental test. This research may lead to the improvement of quality of experiments.

3. THE MATHEMATICAL MODEL OF THE PROCESS.

It’s known that the difference of pressure on a strangulation is a proportional with the square fluid speed. Taking into account the voltage offset of transducers, the analytic model in stationary regime of process is:

$$(3)\;\; h(Q) = \delta h + \beta(Q - \delta Q)^2$$

where Q is the flow, h is maximum liquid level in the work basin, β is strangulation constant, δh is the static error of level transducer and δQ is the static error transducer of flow. Strangulation constant β can be modified by rotating the spherical valve.

The dynamic model of process is inferred from the equation of balance written for flow:

$$(4)\;\; h(t) = h(0) + \frac{1}{T_i}\int_0^t \left(Q_i(t) - Q_e(t)\right) dt$$

where T_i integration time constant, $Q_i(t)$ is the input flow and $Q_e(t)$ is the out flow influenced by the spherical valve. If the position of spherical valve doesn't modify and if the function parameters are known (3), β, δh and δQ, then the out flow is calculated with formula:

$$(5)\;\; Q_e(t) = \delta Q + \sqrt{\left(h(t) - \delta h\right)/\beta}$$

4. THE EXPERIMENTAL RESULTS

In the identification of the stationary process the objective function has been used:

$$(6)\;\; f(x) = \frac{1}{K}\sum_{k=1}^{K}\left|\hat{h}(Q_k) - h_k\right|$$

where K is the number of the static points of measure, the estimated value level $\hat{h}(Q_k)$ is calculated with function (3), and Q_k and h_k are the measured values of flow and level. During the

experiment, the position of spherical valves doesn't modify.
The experiment consists of the following succession of operations:

- supply the motor with a constant voltage;
- wait until the system gets to a stationary regime;
- measure the signals given by the level and flow transducers;
- modify successively voltage of input motor and repeat the previous operations.

Have been made determinations in nine operation static points. Experimental data can be found table 1. In the second column of the table there by the level value and in the third column flow value.

	h	Q
1	0.45	2.10
2	0.45	3.00
3	0.65	3.60
4	1.70	4.20
5	3.00	4.90
6	4.20	5.50
7	5.20	5.90
8	6.10	6.30
9	7.00	6.50

Table 1. Experimental data used in identification.

The processing of data was made with a genetic algorithm SGA. The genetic algorithm was run in the following conditions: the crossover probability $p_c=1$, the mutation probability $p_m=0.05$, the maximum number of generations $t_{max}=100$, population size N=100, the number of individuals from the new generation M=50, the size of elite group E=1. The chromosome has 32 bits, and the three β, δh and δQ parameters were coded with 12, 10 and 10 bits.

The objective function was changed into an fitness like function with transform function:

$$(7)\ \ f_{max}(x) = \frac{1}{1 + f_{min}(x) - f_{min}(x_{min})}$$

The evaluation of population is mode in two stages:

- calculate all values of objective function $f_{min}(x_i)$, for P_t population and wrote down the current minimum value in generation t, mark $f_{min}(x_{min})$;

- for each individual calculate the value of fitness function with formula (7).

The selection was made using the biased whell method.

Figure 2 presents the identification result of the stationary characteristic of the laboratory stand. On the upper line the signal voltage is to be found given by the transducer of flow and on the horizontal line the value signals voltage given by the transducer of level. The nine static point of operation used for the model identification, are represented by dots. The obtained parameters are: β=0.33, δh=0.284V and δQ=2.24V. The figure shows that the dots are very close to the parable, and the residue of objective function is $f(x_{min})$=0.101V.

The result of identification stationary process is a parable, but only the ascending branch of the parable has the physical sense since the liquid flows in one direction in the laboratory stand. The static errors δh and δQ cannot be determined precisely through direct measurements but as a result of the identification of the stationary process.

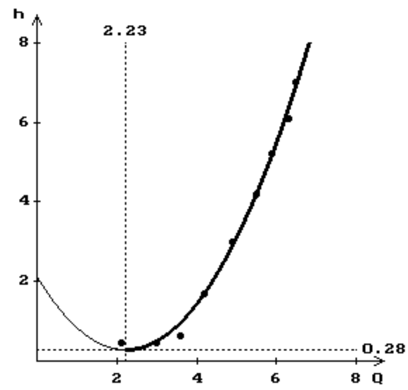

Fig. 2. Stationary feature process.

5. A NEW TRANSDUCER OF LEVEL

In figure 3 is presented the new transducer of level scheme. The sensitive element of transducer is a sounder build with an teflon insulated copper wire, it is stretched on a metallic support. The capacitive value, C_x, between the copper wire and water is:

$$(8)\ \ C_x = C_0 + C_1 \cdot \frac{h}{h_{max}}$$

Where h is the wet length of capacitive sounder, and h_{max} is the maxim wet length. The scheme is consisted the next functional blocks:

- IC1 is an square wave oscillator with frequency of approximate 1kHz with a fill factor 9/10.
- IC2 is a comparator with open collector exit, which discharge periodic the capacity C.
- IC3 is a comparator which detect the moment in which C_x voltage exceeds 2/3 of supply voltage. The output signal from comparator IC3 is a train of impulses level depending duration and with calibrated amplitude.
- IC4 is an substracting amplifier which limit the frequency band of the signal to 6Hz and allow the

continuous component compensation of the level – depending output signal.

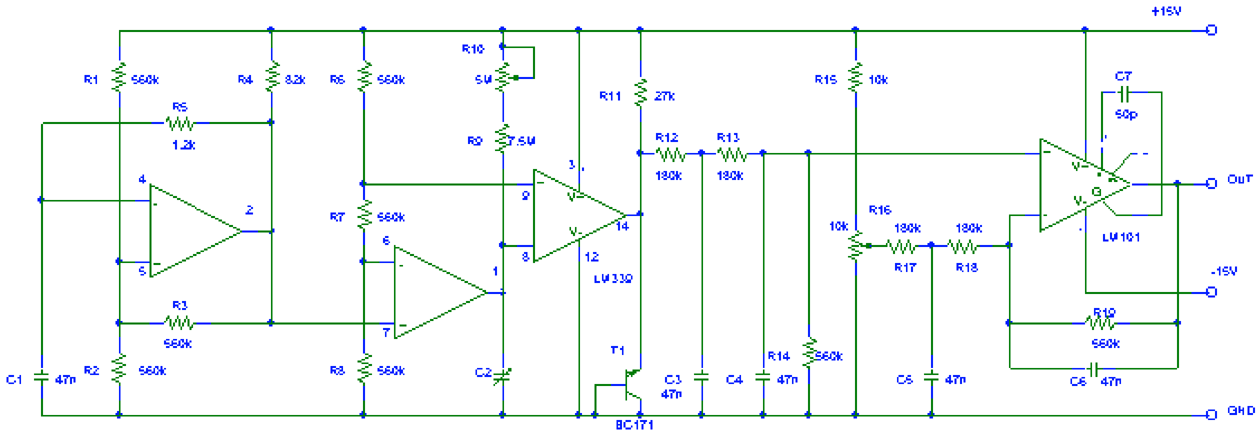

Fig. 3. The scheme a new transducer of level

In figure 4 is presented: v_g, the output signal from generator builded with circuit IC1, v_c, the signal from the capacitor C represented for level h_{min} and h_{max} and v_z, the square wave signal from output comparator IC3 represented in same condition.

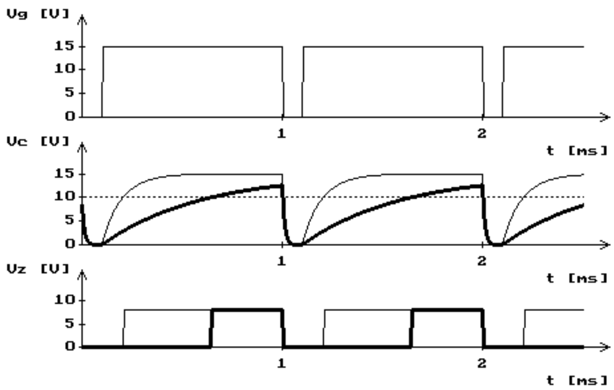

Fig. 4. The signals v_g, v_c and v_z

The capacities C_0 and C_1 from equation (8) are two constant of the sounder which depend on the characteristic of the insulated conductor. Also the capacity C_0 depends of h_{min}, the minimum level of water from basin, and the capacity C_1 depends of h_{max}, the maximum level of water in basin. For the compensation influences variations capacities C_0 and C_1 in scheme there are two potentiometers R_{10} and R_{16}. From scheme and from equation (8) calculated influential potentiometers R_{10} and R_{16} about output tension:

$$V_{out} = C_x \cdot \frac{R_9 + \alpha_{10} \cdot R_{10}}{T} \cdot V_{ref} - \frac{\alpha_{16} \cdot R_{16}}{R_{15} + R_{16}} \cdot 15\text{V} \tag{9}$$

where T is the period square wave signal generated by IC1, V_{ref} is the tension of reference, $\alpha_{10}, \alpha_{16} \in [0,1]$ are the angles of rotation ale potentiometers R_{10} and

• minimum level influence about capacity C_0 is compensated adjust the signal V_{out} at zero from the tuning potentiometer R_{16}, when the level is h_{min};
• maximum level influence about capacity C_1 is compensated regulated the signal V_{out} to the value 10V through tuning potentiometer R_{10}, when the level is h_{max}.

6. CONCLUSION.

In the research presented in this work the next result is obtained:
• the identification of the parameters in stationary regime the models (3) permits the projection on analytic of a Fuzzy controller for adjusting levels.
• the new transducer of level ameliorates the performance of the stand;
• a regularized methodology of calibrating the level transducer;
In future is necessary to design a new flow transducer, more sensitive at low flow.

7. REFERENCES

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