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RESEARCH OF EARLY STAGES OF MODELING

Nikolaev A.B., Stroganov V.Yu., Berner L.I.,
Yakunin P.S., Barinov K.A.

In represented article the questions of estimate of accuracy of an average integral characteristics of random process in the course of imitation modeling is considered. For the purposes of analytical treatment of initial stage of modeling a conditionally nonstationary Gaussian process is analyzed as stationary Gaussian process with boundary prehistory. A model of approximant autocorrelation function is recommended. Analytical expression for variance and mathematical expectation of average integral estimation are obtained. Statistical estimation efficiency criterion, the probability of belonging to correct parameter interval is introduced. Dependences of closeness in estimation statistics clearing interval at transient behavior are researched for various types of processes.

Keywords: *simulation experiment; Gaussian process; autocorrelation function; queuing networks; the trend is a random process.*

Introduction

Experiment planning on imitation model [1, 2] supposes a range of problems solving, connected with estimated accuracy, that is: necessity for taking account of correlation data of imitation output process; necessity for taking account of transient at the initial stage of modeling; the choice of modeling interval and others. In the present paper the research of transient behavior influence is fulfilled, which includes network model of queuing [3, 4], on accuracy of middle integral estimation [5, 6]. Transient behavior of statistics nulling on one hand decreases bias of the estimate, on the other hand, it cancels out statistics collection interval and leads to the increase of dispersion [7]. Thus, the trade-off problem is arises.

That is expected that modeling of initial stable processes is performed [8]. Nonstationarity appears only by means of choice of initial conditions modeling [9]. Besides it is expected that interest is called for middle integral estimate of settling behavior in view of (under known autocorrelation function and its developments r_1 and r_2):

$$r(t) = \sigma^2 \left(\alpha_1 e^{\ c_1 t} + \alpha_2 e^{\ c_2 t}\right), r_1(t) = \sigma^2 \ \frac{\alpha_1}{c_1} e^{\ c_1 t} \ \ \frac{\alpha_2}{c_2} e^{\ c_2 t},$$

$$r_2(t) = \sigma^2 \ \frac{\alpha_1}{c_1^2} e^{\ c_1 t} \ \ \frac{\alpha_2}{c_2^2} e^{\ c_2 t}$$

with parameters of variance of middle integral estimate $\langle_1$, $\langle_2$, c_1 and c_2 will be as follows:

$$D_S \zeta(T) = \frac{2}{T} r_1(0) \ \ \frac{2}{T^2} r_2(0) + \frac{2}{T^2} r_2(T).$$

For conditionally nonstationary process [7, 9, 10] with boundary start conditions on the basis of theorem on normal correlation for mathematical expectation the correct correlation is:

$$M\{\xi \mid S\}(t) = M\xi + D_{\xi\theta}(t) \ \ D_{\theta\theta}^{\ 1} \ \ (S \ \ MS) = y + D_{\xi\theta}(t) D_{\theta\theta}^{\ 1} \ \ (S \ \ yE), \quad (1)$$

where y is stationary process expectation and E is column vector of unity element with dimensionality $(m+1)$, and $S=(S_0, S_{-1}, \dots , S_{-m})^T$ determines value of basic process $\lfloor(t)$ at the moments $St^{=}\langle t_0, t_{-1}, \dots, t_{-m}\rangle$, $(t_0 > t_{-1} > \dots > t_{-m})$.

Covariance function of the process is defined by the following formula:

$$R(t,u) = r(|\,t \ \ u\,|) \ \ D_{\xi\theta}(t) \ \ D_{\theta\theta}^{\ 1} \ \ D_{\xi\theta}^{T}(u), \ \ (t \ \ t_1, u \ \ t_1), \quad (2)$$

where $D_{\lfloor\lfloor}(t)=(r(t-t_0), r(t-t_{-1}),\dots, r(t-t_{-m})$ is a row vector of co-variance and $D_{\lfloor\lfloor}=||$***cov*** $(\lfloor(t_i), \lfloor(t_j))||=||r(t_i-t_j)||, i,j=0..-m$ is a co-variance matrix for instant of time t_i, t_j. Herewith for conditional stable process, the variance of middle integral estimation will be defined by double integral from covariance function (2).

Methodology

In the case of statistics clearing transition period Δ mathematical expectation of middle integral estimate be $M\zeta(T,\Delta) = = \frac{1}{T-\Delta}\int_{\Delta}^{T} M\xi(t\,|\,t_0, S_0)\,dt$ and the variance on the basis (2) be $D\zeta(T)=D\zeta_S(T)\text{-}D\zeta_N(T)$. With this stationary constituent of variance be $D_S\zeta(T,\Delta) = \frac{1}{(T-\Delta)^2}\int_{\Delta}^{T}\int_{\Delta}^{T} r(|\,t-u\,|)\,dtdu$ and introducing the function $W(T,\Delta) = \frac{1}{T-\Delta}\int_{\Delta}^{T} D_{\xi\theta}(t)\cdot dt$ for nonstationary constituent the proportion will be true:

$$D_N\zeta(T,\Delta) = W(T,\Delta) \quad D_{\theta\theta}^{\;1} \quad W^T(T,\Delta). \tag{3}$$

For the autocorrelation function r(t) for the stationary component of the variance of the average integral evaluation after few generations we get:

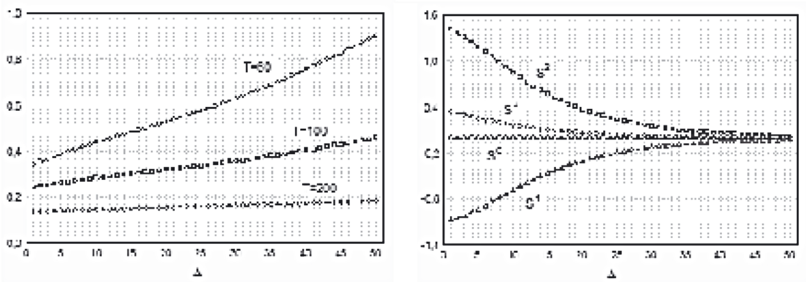
$$D_S(\Delta,T) = \frac{2}{T \quad \Delta} r_1(0) \quad \frac{2}{(T \quad \Delta)^2} r_2(0) + \frac{2}{(T \quad \Delta)^2} r_2(T \quad \Delta). \tag{4}$$

As a consequence of worked in correlations obtained the value of function W for nonstationary constituent of variance and mathematical expectation that afford to carry out an analysis of influence of clearing statistics on efficiency of estimation procedure [8, 11, 12].

Thus, mathematical expectation and variance of estimation should be considered as a function of variables Δ, *St, S, Cv*=(c_1, c_2), *T:*

$$\boldsymbol{M}\zeta(\Delta) = \boldsymbol{M}_\zeta(\Delta|St,\, S,\, Cv,\, T),$$
$$\boldsymbol{D}\zeta(\Delta) = \boldsymbol{D}_\zeta(\Delta|St,\, Cv,\, T).$$

As long as variance value is independent of initial data of modeling, we shall estimate a correlation influence Cv^1=(0.2, 0.1), Cv^2=(0.4, 0.3) and total modelling time $T \in \{60, 100, 200\}$.



a) variance **b)** mathematical expectation

Fig. 1. Influence of size statistical clearing on characteristics of middle integral estimate with Cv=(0.2, 0.1)

From diagrams it is clear, that interval size of statistics clearing is essentially reflected on variance of estimate. Anyway clearing of annual statistics increases the estimate variance, that is it decreases closeness in estimate.

In figure 1b graphs of mathematical expectation of middle integral estimation of process in dependence of interval clearing are reported. Duration value of modeling interval is T=200, as first state were chosen: St=(0, -1); S^0=(0,0), S^1=(5,0), S^2=(5,5), S^3=(0,5).

From diagrams is clear that mathematical expectation of estimation bias also essentially depends on interval size of clearing. Interval size of statistics clearing depreciates an accuracy error estimation of an estimated mean.

In such a way, the problem of choice of anterior statistics clearing interval in view of criteria contradictories demands building of some fold of initial criteria [12–14]. As such fold it is supposed to use probability of valuation entering in specified error interval [15, 16].

Results

Let estimate the probability that, estimation value in the result of modeling will belong to ™-neighborhood of middle y-function value. This probability may be considered as the selection criterion of interval size of statistics clearing [9, 10, 17]. The higher the probability, the all the more precise is the estimated mean.

Probability of belonging of the estimation ™-neighborhood is:

$$P(\delta) = \frac{1}{\sqrt{2 \pi D\zeta(\Delta)}} \int_{y-\delta}^{y+\delta} \exp\left(-\frac{(t - M\zeta(\Delta))^2}{2D\zeta(\Delta)}\right) dt$$

In this connection $P(\delta)=\mathbf{P}(\delta|T, St, S, Cv, \Delta)$. Let's make complete 4^4 factorial experiment with values of all parameters on 4 levels for research of assigned dependence. The adjusted values of variable factors are listed in the table 1.

Table 1.

Factor score

	factor 1	factor 2		factor 3		factor 4	
	T	Δ(D)	δ(G)	S*10		Cv*10	
N			*100	s(0)	s(-1)	c1	c2
1	300	0	0.2	0	0	0.2	0.1
2	350	50	0.25	0	5	0.3	0.2
3	400	100	0.3	5	5	0.4	0.3
4	450	150	0.35	5	0	0.5	0.4

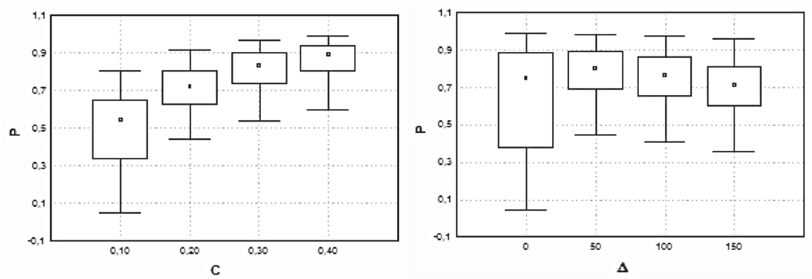
Values of interaction factors are listed in the table 2.

Table 2.

Interaction factor effects

One-factor		Two-factor		Three-factor	
1	0.159723	12	0.001759	123	0.000000
2	0.288725	13	0.000000	124	0.000250
3	0.000000	23	0.000000	134	0.000000
4	1.908926	14	0.001808	234	0.000000
		24	0.241754		
		34	0.000000		

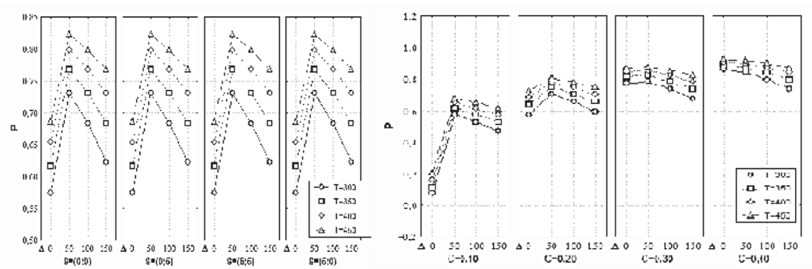
From the table 2 it is clear, that the most essential factor is the process correlation. Start conditions slightly influence on criterion value. From two-variable cooperation the essential is the combination of correlation and interval size of clearing. Diagrams of Boks-Koks of one-factorial influences for ™=0.3 are reported in figure 2. From diagrams we may see, that there are exist some optimum of clear interval size.



a) Influence Cv **b)** influence Δ

Fig. 2. One-factor analysis of interval membership probability

The optimum is represented on the picture 3 more intuitively. Here deduced graphics of neutralized in all values of probability in specified interval correlation for each start condition and modeling interval size and dependencies graphics of probability, averaged throughout for start conditions and each correlation value and each modeling interval size [18–20].



a) on initial condition **b)** on correlation

Fig. 3. Averaged impact assessment of statistics clearing

Discussion

From the graphs, it is clear, that for small values of covariation the optimum of clear interval belongs to neighborhood of zero, that is failure of taking in account of any values of transition period leads to the probability decrease. Moreover, short durations of interval modeling make an optimum clearer.

For the case of necessity in crude estimates attaining of central tendencies, computations in conditions: σ=1were made, short modeling interval (T=100), wide confidential interval (δ=0.5), slightly correlated process Cv=(0.4; 0.5). Probability of estimation entering in the δ-neighborhood for various start conditions S^0=(1, 1), S^1=(1, 3), S^2=(3, 1), S^3=(5,5) is investigated. Was demonstrated that for state S^0 all data S_3 should be taken in account (sufficiently far initial conditions) optimal interval of nulling is equal only 4–5 units of 100.

Conclusion

The analysis of mathematical expectation of middle integral estimation of conventional nonstationary process upon condition of statistic clearing is made, which is cumulated at start modeling interval, which is Δ. Analytical expectations of mathematical expectation and middle integration estimation variance in dependence from value Δ are received. As the result of researches it is clear, that the increase Δ decreases systematical error, but increases estimation variance. Therefore it is offered to make fold of both values by means of determination of probability that the estimate value in the result of modeling and anterior statistics clear will belong to δ-neighborhood of stationary value. The set of experiments is carried on with the aim of revelation of factors, which influence this index.

Ii is testified that determining factor is the degree of process correlation: with strong correlation a clear is necessary, however with wide confidential interval and weak correlation there is no necessity in statistics clear execution. With small correlation values the optimum of interval clearing of initial-value, belonging to neighborhood of zero. Thus, statistical and analytical models of output imitation processes, offered in the article, allow essential widening the sphere of researches of various procedures of imitation modeling organization, and building of keeping under control and optimizing algorithms.

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DATA ABOUT THE AUTHORS

Nikolaev Andrey Borisovich, Honoris Causa, Doctor of Technical Sciences, Professor, Head of Department
State Technical University – MADI
64, Leningradsky prospekt, Moscow, 125319, Russian Federation
nikolaev.madi@mail.ru

Stroganov Victor Yurevich, Laureate of the Government Prize of the Russian Federation, Doctor of Technical Sciences, Professor of the Department «Systems of Information Processing and Management»
Bauman Moscow State Technical University – National Research University
5, 2 Baumanskaya Str, Moscow, 105005, Russian Federation
str.madi@mail.ru

Berner Leonid Isaakovich
Closed joint-stock company «Atlantiktransgazsistema»
11, Polbina Str., Moscow, 109388, Russian Federation

Yakunin Pavel Sergeevich
State Technical University – MADI
64, Leningradsky prospekt, Moscow, 125319, Russian Federation
vashome@yandex.ru

Barinov Kirill Aleksandrovich
State Technical University – MADI
64, Leningradsky prospekt, Moscow, 125319, Russian Federation