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QUANTITY IDENTIFICATION TASK IN WATER MANAGEMENT

An efficient management of river water distribution needs its global identification. The author formulates the quantity identification task with respect to an optional river basin as the object of identification and also presents the algorithm solving this kind of task.

1. INTRODUCTION

The quantity identification task with respect to an optional river basin is formulated below. The identification object has a very complicated structure. The river basin can be considered as a big system, shortly — complex, with a single river as its basic element.

Without loss of generality the quantity identification task is presented with respect to an optional river as a basic element of the complex.

2. QUANTITY IDENTIFICATION TASK

The quantity identification task consists in determining from the quantity states space $\hat{Q}$ the set of most probable states $\bar{q}$. The procedure was considered in all n-basic elements of the complex.

Let $n = 1$. At first the finite-dimensional basic base Q_B was determined as a tool to calculate the set of most probable states $\bar{q}$. The set $\bar{q}$ is a subspace of the $\hat{Q}$ space, and $\bar{q} \subset \hat{Q}$. Next for the given $x = x_1, x_2, \ldots, x_k$ we determine the values $q_1, q_2, \ldots, q_k$ equal respectively $q(x_1), q(x_2), \ldots, q(x_k)$. In the particular case the

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value q_i may represent the kind of average flow in the cross-section with $(x_i, 1)$ coordinates, $i = 1, 2, \ldots, k$.

The value of the norm below

$$\|x_k - x_1\|_Q = |x_k - x_1|$$

equals the length of the basic element.

We can determine the set of $\bar{q}$ states, with respect to finite-dimensional base $Q_B = \{q(x_1), q(x_2), \ldots, q(x_k)\}$, along the basic element:

$$\bar{q} = q^1 \cup q^2 \cup \ldots \cup q^{k-1}$$

where $q^i = F_i(q(x_i), q(x_{i+1}))$, F_i is an analytic function of C^2 class. We can calculate very similarly all n-basic elements.

3. THE ALGORITHM

The solution of the quantity identification task is given as a parametric spline function in the form:

$$q = F(x), \qquad x \in [0, r_i], \qquad i = 1, 2, \ldots, n$$

where

q — average flow (for example annual),

F — general form of the spline function,

x — coordinate of the calculating cross-section on the i' s basic element of the r_i length,

n — number of basic elements in the complex.

We can show the above equation in a more particular form:

$$q = \begin{cases} F_1(x), & x \in [r_{i,1}, r_{i,2}), \quad r_{i,1} = r_i, \\ F_2(x), & x \in [r_{i,2}, r_{i,3}), \quad 0 < r_{i,2} < r_i, \\ & \ldots \\ F_{k-1}(x), & x \in [r_{i,k-1}, r_{i,k}), \quad 0 < r_{i,k-1} < r_i, \\ F_k(x), & x \in [r_{i,k}, r_{i,k+1}), \quad r_{i,k+1} = 0 \end{cases}$$

where $r_{i,j}$, $j = 2, 3, \ldots, k$ are the coordinates of the cross-sections.

The class of F_j-function depends of hydrological characteristics of the basic elements. The F_j functions may have a linear or nonlinear form.

Now we introduce some denotations:

x_i' — coordinate of the cross-section in basic element,

q_i' — average flow in the i' s cross-section; $i = 1, 2, \ldots, n$,

x_i'' — coordinate of the natural or man-made side stream of the basic element,

q_i'' — average flow of the side stream in the x_i''-place,

r — coordinate of the source (the begining of the river) of basic element, 0 — coordinate of the place where the basic element connects with the next one of the higher class.

The algorithm shown below gives the solution of the quantity identification task. The step by step procedure is presented.

Step 1. We obtain data base in form of ordered pairs:

$$(q'_i, x'_i) \in q' \times X', \quad q' \in R^+, \quad X' \in N.$$

This base we denote as Base A.

Step 2. We obtain next data base in form of ordered pairs:

$$(q''_i, x''_i) \in q'' \times X'', \quad q'' \in R^+, \quad X'' \in N.$$

This base we denote as Base B.

Step 3. Now we obtain the Base C as a sum of previous ones:

$$\text{Base C} = \text{Base A} \cup \text{Base B}$$

and next set up the elements of the Base C in monotone decreasing sequence with respect to x-coordinate.

Step 4. We assume that the first and last element of the Base C belong to the Base A.

Let $i = 1$. Then $x_1 = x'_1$ and $q_1 = q'_1$.

Step 4a. If $(q_{i+1}, x_{i+1}) \in$ Base A, then we go to step 5. If $(q_{i+1}, x_{i+1}) \in$ Base B, then we go to step 8.

Step 5. Now the parameters $\hat{a}$ and $\hat{b}$ are calculated:

$$\hat{a} = \frac{q_i - q_{i+1}}{x_i - x_{i+1}}, \quad \hat{b} = \frac{q_{i+1}x_i - q_i x_{i+1}}{x_i - x_{i+1}}.$$

Step 6. Next we approximate the values of $F(x)$ function in the interval $[x_i, x_{i+1}]$ with given increment of x:

$$F(x) = \hat{a}x + \hat{b} \text{ (linear case)}.$$

Step 7. If $i \neq n+k$, then $i = i+1$ and we go to step 4a, otherwise it is the end of calculation.

Step 8. If $q_{i+1} > 0$ (side stream) then we go to step 9. If $q_{i+1} < 0$ (water intake) we take $-q_{i+1}$ as a q_{i+1} and go to step 9.

Step 9. Now we should find such an element $(q_l, x_l) \in$ Base A, that $x_l < x_{i+1}$ with condition that there is no element $(q_j, x_j) \in$ Base A, satisfying inequality:

$$x_l < x_j < x_{i+1}.$$

Step 10. Next the parameters $\hat{a}$ and $\hat{b}$ are calculated:

$$\hat{a} = \frac{q_i - q_l}{x_i - x_l}, \quad \hat{b} = \frac{q_l x_i - q_i x_l}{x_i - x_l}.$$

Step 11. Now we approximate the values of $F(x)$ function in the interval $[x_i, x_{i+1})$ with given increment of x:

$$F(x) = \hat{a}x + \hat{b} \text{ (linear case).}$$

Step 12. In this step we calculate the value of $F(x)$ in the point x_{i+1} using the equation:

$$F(x_{i+1}) = \hat{a}x_{i+1} + \hat{b} + q_{i+1}.$$

Step 13. Now we should check existing value x_{i+2} satisfying the inequality:

$$x_l < x_{i+2} < x_{i+1}$$

and $(q_{i+2}, x_{i+2}) \in$ Base B. If such a value exists, then we go back to step 9, otherwise we go to step 14.

Step 14. Let $i = i+1$ and $i+2 = l$. Next we go to step 5.

The table form of $F(x)$ function is a result of the given algorithm. $F(x)$ is a distribution function of average flow in longitudinal section of basic element. Of course, restricting the function of $F(x)$ to the linear class does not limit the application of the above algorithm. In other than linear classes of $F(x)$ the procedures of finding the efficient estimators of the F's parameters are known.

REFERENCES

[1] GARBULIŃSKI T., *MDRS — Water Pollution Control System*, Environment Protection Engineering Vol. 11 (1985), No. 1.

[2] GARBULIŃSKI T., *Metoda jakościowo-ilościowej identyfikacji zasobów wód powierzchniowych*, Doctoral Dissertation (typescript).

ZADANIE ILOŚCIOWEJ IDENTYFIKACJI W ZARZĄDZANIU ZASOBAMI WÓD POWIERZCHNIOWYCH

Efektywne zarządzanie rozdziałem zasobów płynących wód powierzchniowych wymaga wcześniejszej ich identyfikacji. Autor formułuje zadania ilościowej identyfikacji w stosunku do obiektu, jakim jest dorzecze dowolnej rzeki. Podaje także jedną z propozycji rozwiązania tak sformułowanego zadania.

ЗАДАЧА КОЛИЧЕСТВЕННОЙ ИДЕНТИФИКАЦИИ В УПРАВЛЕНИИ РЕСУРСАМИ ПОВЕРХНОСТНЫХ ВОД

Эффективное управление распределением ресурсов текучих поверхностных вод требует раньшей их идентификации. Автор формулирует задачу количественной идентификации по отношению к объекту, каким является речная система любой реки. Предлагает также решение так сформулированной задачи.