Strategic approximation of sustainable development of ecological systems and industry by expert estimations and genetic algorithm approach

Romanuke V. V., Husak L. P.
Vinnytsia Institute of Trade and Economics of SUTE, Vinnytsia, Ukraine,
E-mail: romanukevadimv@gmail.com

Ecology and industry bond. Commonly, ecological systems are badly affected by industrial objects. Their wastes and byproducts pollute the environment. However, industrial objects are vertices of the impetus of economy development that results in a gross domestic product (GDP). A part of it feeds the protection and support of the ecology. Without the ecology support, industrial pollution grows and eventually subjects of the pollution make additional expenses to recover vanishing resources. Then the GDP starts deteriorating. On the other hand, industrial objects can forcedly invest into ecology only a small part of their profit, because otherwise an annual GDP will be under-received. So, ecology and industry are in a bond whose balance is important for development of both.

The strategy of sustainable development. By a hard logic pattern of production, an industrial object applies either an ecologically clean mode or does not apply it polluting the environment. The clean mode has its cost, but the non-clean mode may result in all the objects (being the subjects of the pollution) are fined when the total volume of pollution exceeds its limit set by the government. The fining is imposed regardless of a subject has applied the clean mode or not. The subjects thus virtually interact through their pollutions choosing between clean and non-clean modes. A model of the interaction among N subjects is an N-person dyadic game [1] whose payoffs represent losses of the subjects. The losses include both clean mode costs and potential fines. Here, let q_k be a probability of selecting the clean mode by subject k, $q_k \in [0; 1]$, $k = \overline{1, N}$. A set $\{q_k\}_{k=1}^{N}$ is a situation in the dyadic game, and $\varphi_k\left(\{q_i\}_{i=1}^{N}\right)$ is an expected loss (fine) of subject k for the damage to the ecology in this situation. The loss function of subject k is an N-dimensional matrix $\mathbf{F}_k = [\, f_{k\Omega}\,]_{\mathrm{S}}$ of size $\mathrm{S} = \bigtimes_{n=1}^{N} 2$ by indices $\Omega = \{\omega_k\}_{k=1}^{N}$, $\omega_k \in \{1, 2\}$ $\forall\, k = \overline{1, N}$. The expected loss is calculated as

$$\varphi_k\left(\{q_i\}_{i=1}^{N}\right)=\sum_{\omega_k=1,\,2,\,k=\overline{1,\,N}}\left(f_{k\Omega}\cdot\prod_{i=1}^{N}q_i\right).$$

The goal is to find $\{q_k^*\}_{k=1}^{N}$ such that the sum

$$\sum_{k=1}^{N}\varphi_k\left(\{q_i^*\}_{i=1}^{N}\right)=\sum_{k=1}^{N}\varphi_k^*$$

be minimal and simultaneously individual losses $\{\varphi_k^*\}_{k=1}^{N}$ be as close as possible [2].

Expert estimations. The N matrices can be estimated by using the expertise of industry practitioners and governors. As there are only two pure strategies $q_k=1$ and $q_k=0$, the total number of all entries is $N\cdot 2^N$. So, it is not difficult to conduct such estimation procedures and analyze them for the consistency. The loss scale can be binary with an option to omit some estimates, wherein the null estimate is then assigned to the averaged value of the scale. For instance, a quarter of $N\cdot 2^N$ estimate cells in the questionnaire can be optional. The estimation procedures can be conducted through specific groups in social networks. A database for expert estimations must include a list of expert groups, all experts enumerated and assigned to those groups, and a list of estimation procedures. The database is used to trace successfulness of estimation procedures and to redistribute weights of experts in order to calculate the most reliable estimates of the loss matrices.

Genetic algorithm approach. Generally, it is impossible to find $\{q_k^*\}_{k=1}^{N}$ but an approximately best situation $\{\tilde{q}_k^*\}_{k=1}^{N}$ is determined by using the genetic algorithm (Fig. 1). To binarize the probabilities, conversions $0=(00\ldots0)_2$ and $1=(11\ldots1)_2$ are used [3, 4]. The algorithm returns the most rational ecology-favorable strategy for every subject and approximates thus the sustainable development of ecology and industry.

Discussion and conclusion. Despite the dyadic game model is seemingly very simple, it is a way to balance the requirements of ecological systems and needs of industry. Practical implementation of situation $\{\tilde{q}_k^*\}_{k=1}^{N}$ relies on every probability has a finite number of digits after decimal point. Then the subject implements its most rational strategy through the process of randomly combining pure strategies $q_k=1$ and $q_k=0$ with respect to the fraction in the probability. However, the time span of the implementation process is extended as the representation accuracy of probabilities $\{\tilde{q}_k^*\}_{k=1}^{N}$ is improved [1].

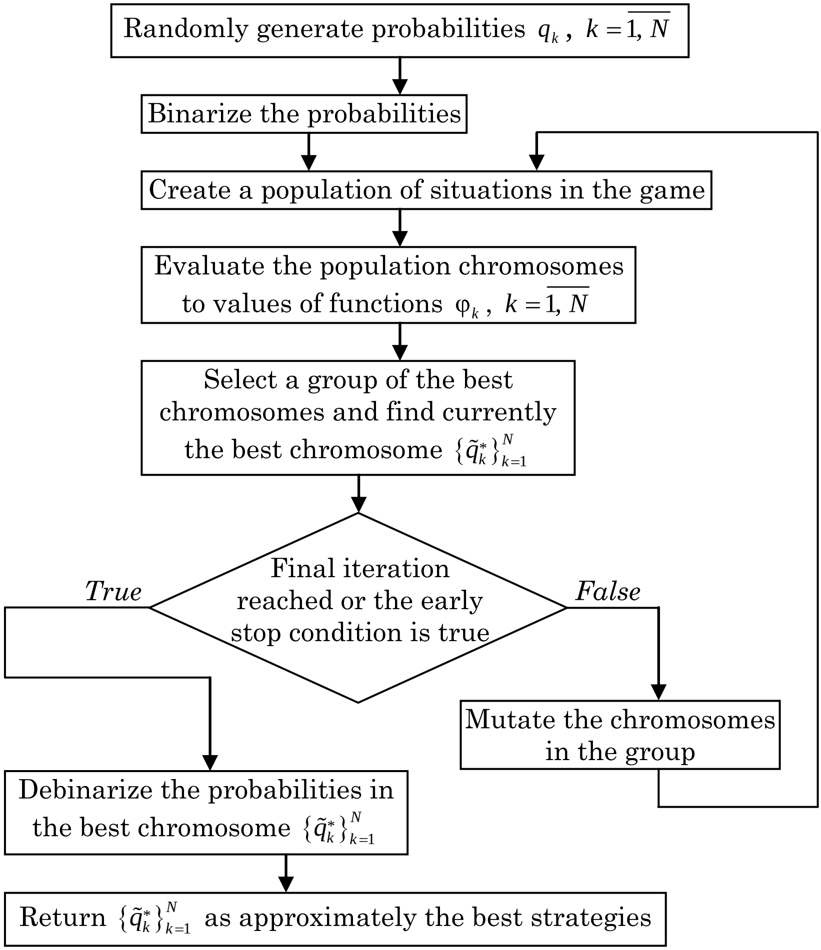

Fig. 1. The flowsheet to find approximately the best solution

The more accurate strategic approximation of sustainable development of ecological systems and industry lasts longer. The time unit during which the mode is unchangeable depends on the industrial production branch. Usually the shift of the mode becomes possible after a day or a few days, week, month. The time span of achieving the sustainable development stabilization is shortened by increasing the frequency of the subject functioning mode shift [1].

References

1. Romanuke V. V. Ecological-economic balance in fining environmental pollution subjects by a dyadic 3-person game model // Applied Ecology and Environmental Research. — 2019. — Vol. 17, No. 2. — P. 1451 — 1474.
2. Romanuke V. V. A couple of collective utility and minimum payoff parity loss rules for refining Nash equilibria in bimatrix games with asymmetric payoffs // Visnyk of Kremenchuk National University of Mykhaylo Ostrogradskyy. — 2018. — Iss. 1 (108). — P. 38 — 43.
3. Haupt R. L., Haupt S. E. Practical Genetic Algorithms. — John Wiley & Sons, 2003. — 253 p.
4. Michalewicz Z. Genetic Algorithms + Data Structures = Evolution Programs. — Berlin: Springer, 1996. — 388 p.

Використання ГІС технологій при проведенні інженерно-геодезичних вишукувань руйнувань цивільної інфраструктури

Андрєєв С.М., Діденко Д.Д.
Національний аерокосмічний університет «Харківський авіаційний інститут» ім. М. Є. Жуковського, E - mail: didenko10den@gmail.com

Уже нині треба розуміти, як можна відбудовувати державу після масштабних руйнувань агресором, обмірковано обрати найкращий вектор дій і створити конкретний план завчасно, щоби після перемоги якомога швидше втілювати його в життя.

Актуальним питанням стає створення цифрових моделей та геоінформаційних систем цивільної, транспортної та критичної інфраструктури, які в подальшому можуть використані для створення єдиної бази руйнувань, відновлення архітектури, транспортних вузлів, перевірка та аналіз якості будування тощо. [1] Для отримання достовірних даних потрібно максимально точно та якісно провести польові та камеральні роботи. Наразі є купа способів отримати вхідні дані, такі як: тахеометрична та GNSS зйомка, повітряне, мобільне та наземне лазерне сканування. Для отримання достовірних даних під кожну задачу потрібно обрати раціонально правильний спосіб знімання об’єкту.

На сьогоднішній день, лазерне сканування - це найпродуктивніший спосіб отримання точної та повної інформації про просторові об'єкти. Суть технології полягає у визначенні просторових координат точок поверхні об'єкта (будівель, споруд, інфраструктури, територій). Результатом роботи сканера є масив (хмара) точок лазерних відображень від об'єктів, що знаходяться в полі зору сканера, з п'ятьма характеристиками, а саме просторовими