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APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN ANALYZING AND FORECASTING MARKET NEEDS FOR DRUGS AND MEDICAL PRODUCTS

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ABSTRACT

Proper management of enterprise resources, competent management of production and marketing can greatly contribute to the modernization of the pharmaceutical industry of our country and the conquest of the pharmaceutical market with drugs produced in our country. Planning of production and sale of pharmaceutical products is important for pharmaceutical companies. Effective development of enterprises is hindered without proper sales planning. Sales planning is important in business activities. As a rule, sales are the main source of financial income. To maximize the effectiveness of sales planning, the plan should be realistic and appropriate to the company's resources. In this work, artificial intelligence methods were studied in the optimal forecasting of the production and sale of pharmaceutical products.

Keywords. *drugs, artificial intelligence, optimal forecasting, demand, need, income, fuzzy set, objective function.*

АННОТАЦИЯ

Грамотное управление ресурсами предприятия, грамотное управление производством и маркетингом могут в значительной степени способствовать модернизации фармацевтической промышленности нашей страны и завоеванию фармацевтического рынка препаратами, произведенными в нашей стране. Планирование производства и реализации фармацевтической продукции важно для фармацевтических компаний. Без надлежащего планирования продаж тормозится эффективное развитие предприятий. Планирование продаж играет важную роль в коммерческой деятельности. Как правило, продажи являются основным источником финансового дохода. Чтобы максимизировать эффективность планирования продаж, план должен *быть реалистичным и соответствовать ресурсам компании. В данной работе изучались методы искусственного интеллекта в оптимальном прогнозировании производства и реализации фармацевтической продукции.*

Ключевые слова. *лекарства, искусственный интеллект, оптимальное прогнозирование, спрос, потребность, доход, нечеткое множество, целевая функция.*

INTRODUCTION

The health of the population has always been and remains one of the most important components of the life of the country and society. Healthcare is one of the leading branches of the social sphere. Its main task is to improve the situation in the health sector and create conditions for its further modernization. In the realization of such a goal, the personal participation of each person is important [1].

It is of great importance to create and distribute informational and intellectual systems for the introduction and quality assessment of pharmaceutical products produced all over the world. The development of the methodological foundations of a comprehensive approach to the creation of systems for continuous product quality assurance (at all stages of the life cycle) in the chemical and pharmaceutical industry is a new urgent scientific problem that fulfills important scientific-technical, organizational and scientific tasks [2].

The purpose of the study is to increase the efficiency and profit of enterprise management, taking into account the specific characteristics of the production of medicines, as well as to develop fuzzy methods and models for optimal planning of the production and sale of pharmaceutical products; determination of the main features of production and sale of products in pharmaceutical enterprises, as well as analysis of existing economic-mathematical models suitable for use in pharmaceutical enterprises; development of a heuristic algorithm for rapid planning of production and sale of pharmaceutical products; consists of developing a model and algorithm for optimal planning of production and sale of pharmaceutical products.

According to analysts, the world pharmaceutical market is growing steadily and increases by an average of 7.8% annually. The growth in developing countries was significant. The trade volume of Brazil, China, India and Russia increased by 22.6%, while the trade volume of the remaining 13 developing countries increased by 7.2% [1].

In the early stages of drug discovery, machine learning can perform many tasks, from initial observations of drug compounds to predicting drug success. Artificial intelligence can play a role in drug identification and validation tasks, such as drug repurposing and biomarker detection. Applying artificial intelligence to drug testing can shorten the time it takes to get a drug approved and on the market, thereby reducing overall costs. An artificial intelligence system for the production of drugs should take into account the following characteristics of slow processes [2,3]:

- They are multifactorial and multidimensional.
- Extensive use of modern mathematical models, digital methods and information technologies based on artificial intelligence methods.

METHODS

From the drug development process to the purchase of the drug by the patient at the pharmacy, the pharmaceutical industry has to work with a huge amount of data. Laboratory diagnostics, monitoring of patients' condition, messages about the drug's effectiveness on forums and social networks - all this is useful information for a pharmaceutical company. However, given their quantity and fragmentation, the manufacturer does not have time to process and absorb this knowledge, much less apply it. Artificial intelligence helps to solve these and other problems [1,2].

The desire of pharmaceutical companies to collect, systematize and analyze large data has forced them to turn to artificial intelligence technologies. The neural network created by scientists can easily cope with collecting the necessary information both in the creation of the drug and in obtaining feedback from patients [3].

Another task where artificial intelligence can be useful is to reduce drug development time [4-9].

The optimal planning model for the sale and production of pharmaceutical products was developed.

$$f_1 = \sum\sum \mu_{ij} x_{ij} \to \max$$
$$f_2 = \sum\sum r_{ij} x_{ij} \to \min \qquad (1)$$
$$f_3 = \sum\sum \upsilon_{ij} x_{ij} \to \min$$

subject to

$$0 \le \mu(x), r(x), \upsilon(x) \le 1,$$
$$\sum_j x_{ij} = S_i\,, \qquad (2)$$

where S_i denotes the sentence of source i,

$$\sum_j x_{ij} = D_i\,, \qquad (3)$$

where D_i denotes the demand of destination j,

$$x_{ij} \ge 0 \quad .$$

Here:

μ_{ij} - i - the selling price of product

$x_{i,j}$ - the amount of i-type manufactured products in the j-stage

r_{ij} - production costs of i-type product

v_{ij} - costs of certification of the same type of products

Solving this problem can be done using the fuzzy programming method, which allows to find the optimal solution of multi-level problems.

Solution algorithm.

Step 1: Solve a multiobjective optimization problem.

Step 2: Based on the results of step 1, determine the appropriate values for each goal in each resulting solution. Then find the lower and upper bounds of f_k^L, and f_k^U $(k = 1, 2, 3, ..., K)$.

Step 3: The membership function $\mu_{k(x)}$ corresponding to the kth goal of the minimization problem is defined as

$$\mu_k(x) = \begin{cases} 1 & if \quad f_k \le f_k^L, \\ 1 - \dfrac{f_k - f_k^L}{f_k^U - f_k^L} & if \quad f_k^L < f_k < f_k^U, \\ 0 & if \quad f_k \ge f_k^U \end{cases}$$

The membership function can be defined for the maximization problem as

$$\mu_k(x) = \begin{cases} 0 & if \quad f_k \le f_k^L, \\ 1 - \dfrac{f_k - f_k^U}{f_k^U - f_k^L} & if \quad f_k^L < f_k < f_k^U, \\ 1 & if \quad f_k \ge f_k^U \end{cases}$$

The linear programming problem can be further simplified as follows.

$$\lambda \to \max$$

$$f_k + \lambda(f_k^U - f_k^L) \le f_k^U$$

for the minimization problem and

$$f_k + \lambda(f_k^U - f_k^L) \le f_k^L$$

for a maximization problem with given constraints and

$$\lambda \ge 0.$$

Step 3 gives the values of the three objective functions f_1, f_2 and f_3.

Step 4:

$$f = f_1 - f_2 - f_3$$

RESULTS.

Consider the fuzzy optimization problem

odds_coefficient = [[1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,0],
[0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
[0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0],
[0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0],
[0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0],
[0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,0],
[0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0],
[0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0],
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1],
[1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0],
[0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0],
[0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 0 0],
[0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1]]

$\mu_{ij} =$

0.6	0.7	0.3	0.8
0.5	0.4	0.5	0.3
0.4	0.3	0.6	0.7

$r_{ij} =$

0.1	0.2	0.3	0.1
0.2	0.1	0.3	0.3
0.3	0.2	0.3	0.3

$v_{ij} =$

0.2	0.1	0.1	0.1
0.3	0.1	0.1	0.2
0.2	0.2	0.1	0.2

The goal of this task can be determined by the degree of acceptability $\mu_o(x)$, the degree of uncertainty $r_o(x)$ and the degree of deviation $\upsilon_o(x)$ of the cost function:

$$\mu_o(x)=\begin{cases}1, & \sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}<220\\ \dfrac{(300-\sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij})}{140}, & 220\le\sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}\le 300\\ 0, & \sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}>300\end{cases}$$

$$r_o(x)=\begin{cases}0, & \sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}<240\\ \dfrac{(\sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}-240)^2}{140}, & 240\le\sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}\le 330\\ 1, & \sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}>330\end{cases}$$

$$r_o(x)=\begin{cases}0, & \sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}<200\\ \dfrac{(\sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}-210)^2}{140}, & 210\le\sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}\le 330\\ 1, & \sum_{i=1}^{3}\sum_{j=1}^{4}C_{ij}x_{ij}>330\end{cases}$$

The solution is obtained as

$$\lambda=0.91,$$
$$f_1=513.27,$$
$$f_2=137.32,$$
$$f_3=111.57$$
$$\mu_o=0.71, r_o=0.0032, \upsilon_0=0.139$$

The main advantage of fuzzy goal programming is that it can be transformed into a traditional linear programming model. Another advantage is that setting goals is symmetric with setting constraints. Finally, the concept of allowable degraded aspiration level is compatible with real decision making.

SUMMARY

In the article, the task of developing optimal planning methods and models for the production and sale of pharmaceutical products, as well as creating software tools supporting these models and methods, was set and solved. A fuzzy mathematical model of the optimal planning of the production and sale of pharmaceutical products has been developed, which takes into account the unique characteristics of the industry and maximizes the company's profit; A heuristic algorithm for planning the production and sale of pharmaceutical products has been developed, which is characterized by high speed and planning efficiency.

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