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DESIGNING A CONCEPTUAL MODEL OF AN ANALYTICAL SYSTEM THAT AUTOMATES THE FORECASTING PROCESS IN AGRICULTURE

The study of the subject area and the creation of a conceptual model are important steps in the development of any system, as they help to determine the requirements, functionality and structure of the system, as well as establish a common vision of the project before its implementation. Automation of agriculture requires the development of analytical systems to predict the growth of pest populations, which in turn involves the study of the subject area and the presentation of a conceptual model for the analytical system. The solution to this problem will help automate the work of scientists in the field of agriculture in calculating and predicting the growth of the number of pests of grain crops.

The review of existing conceptual models in various fields of activity, especially in the agricultural sector, is carried out. System requirements have been put forward to ensure high efficiency and reliability of the system.

Keywords: conceptual model, analytical system, forecasting, agriculture, pests, bread striped flea.

Introduction

In the era of intensive development of IT technology, much attention is paid to the development and design of systems that ensure consistency in the sequence of technology applications. The main component of system design is system modeling. Modeling helps to create an abstract representation of the system, including its components, relationships, and processes. Modeling also helps to avoid mistakes at an early stage of development. Creating a model allows you to better organize the development process, determine the sequence of work and manage resources more efficiently. System modeling includes a conceptual, logical, and physical model of the system. The conceptual model should illustrate the most important concepts of the problem area and demonstrate the relevant aspects [1, P. 1–14].

All systems, when studying the subject area and for a full understanding of it, need to design a conceptual model, the diversity of areas, including the ecosystem, covering this process is shown by the work of scientists, including systems such as flood damage assessments in large cities using representative factors such as rainfall intensity and the intensity of natural disasters floods [2, P. 1-11], a mangrove ecosystem degradation system for remote sensing, where the gap between satellite-derived variables and ecosystem degradation is eliminated through clear ecological linkages [3, P. 1–19]. The conceptual model was created for the system of determining the mathematical dependence of the groundwater flow in the lake, as well as the interaction of surface and groundwater [4, P. 1–12]. A conceptual model has also been proposed, which highlights important independent and dependent variables for groundwater quality management in northern Iran. The conceptual model of the groundwater quality determination system shows the interaction of ten factors (types of land use, lithological units, geological units, distance from wells to outlet, distance to residential areas, direction to residential areas, depth of groundwater, type of aquifer, transmission coefficient and population) [5, P. 1–13].

In addition, scientists have proposed a conceptual model as a tool that creates a clear, formalized and systematic representation of a subject area like agriculture. Farms where grazing intensity and timing of major production cycle events are poorly controlled have led to the development of a diagnostic support system for environmental intensification in natural meadows, systems to improve the production and environmental performance of most calf farms in Uruguay

[6, P. 1-11], a ciguatoxin loading system in the Greater Caribbean region that uses empirical field data (temperature, Gambierdiscus cell density, macrophyte cover) to obtain simulation results [7, P. 1–13]. In the agricultural sector, scientists [8, P. 89–102] have proposed a conceptual model based on impulse differential equations to describe the dynamics of populations of susceptible and resistant pests over time. Researchers [9, P. 57–80] synthesized the available literature on a conceptual model of arthropod pest control strategies suitable for organic systems.

By the authors [10, P. 313–356], the presented model was based on the metaphor of a cube and supports geometric shapes and corresponding membership values, which provided a more expressive representation of vague spatial data, in which the application of pest control in agriculture was successfully described.

The model reproduces the properties of the system observed in field studies and shows under what conditions diametrically opposite hypotheses about plant viability and plant stress are confirmed [11, P. 1–12]. A conceptual model based on impulse differential equations was proposed [12, P. 71–82] to describe the dynamics of populations of susceptible and resistant pests over time.

It can be seen from the studied scientific sources that these studies help to develop a conceptual model for system automation, for software development, and various applications in different areas of human activity, in particular ecology, agriculture, and economics [13, P. 1–17], [14, P. 1–18].

The subject area, which uses information systems, applications, and software in its development in general, has a wide range of human activities, including medicine, in which scientists [15, P. 149–160] have shown the application of a conceptual model for an application describing the relationship related to clinical car.

One of these ranges of human activity is agriculture. For the comprehensive diagnosis, treatment and protection of plants from diseases and pests of corn, a conceptual model of an expert mobile application for pest and disease control has been developed [16, P. 1–8].

In the textbooks of A. P. G. Brown, P. Chen and other authors of the 60s and 70s, a conceptual model of the domain was proposed, representing the result of its object decomposition or ER model. The authors [17, P. 1–5] proposed a conceptual software model where, based on user stories, the flexibility of software development is determined, offering the decomposition of models using UML diagrams. In research [18], using the flexible method, a model was shown that can generate various variants of requirements. [18, P. 1–10].

The purpose of this research is to create a formalized and systematized representation of an analytical system for predicting the growth rates of crop pests using a conceptual model. To achieve the goal, the following tasks were set: a) to develop requirements for the design of a conceptual model; b) to develop a conceptual model of an analytical system for pest forecasting.

All the actual material requires automated viewing and analysis in order to optimize the process and perform specific production tasks. In this study, an automated pest prediction system is based on machine learning. By using automated pest control systems, farmers can minimize labor costs, save time and reduce crop risks.

As a result of the development of any system, the problem arises of the correct organization of the interaction of system objects, which leads to the study of the subject area and the design of a conceptual model.

Methods and materials

In carrying out this study, such theoretical methods as analysis and synthesis, as well as modeling were used.

Analytical methods [19, P. 1–14] used at the stage of forming a conceptual model contribute to increasing the reliability of data in substantiating the model being developed. One of the main analytical methods that has found application in the formation of a conceptual model is the method of system analysis.

Analyzing the current state of creation of conceptual models it is revealed that for forecasting and operational management of agricultural production, additional accounting and retrospective information on the yields of relevant crops is provided.

One of the main analytical methods used at the stage of conceptual model formation is also the method of statistical data analysis. The essence of this method is to collect statistical data on the object of study, then quantify the presence or absence of dependencies between the obtained data, and then use the identified dependencies for their mutual linkage within the conceptual model.

In the process of developing an analytical system for predicting the growth of the number of pests of grain crops, all stages of software development were followed. At the first stage of this study, the subject area was studied, that is, data on pests of grain crops, in particular bread fleas, the causes of their spread (reproduction), factors influencing the growth of their numbers, which include location (regions of the Republic of Kazakhstan), soil, climate, and the number of distributions in previous years were studied. In the Republic of Kazakhstan, grain crops are privately grown in the northern, eastern and central regions of Kazakhstan and less often in the southern ones. In the course of the study, consultations were received from scientists in the field of phytosanitary forecasting of population dynamics of pests of grain crops. The harmfulness of bread fleas will largely manifest itself in dry, hot weather during the initial period of growth and development. At this time, the first leaf suffers most from the bread flea. Young plants are noticeably depressed, turn yellow and wither. Early crops are damaged more than later ones. Hence, the factor contributing to the development of the pest is a severe damage to plants by root rot. The next factor is the influence of the weather and climatic conditions of the growing season.

Hence, having studied the subject area, predicting the growth of the number of pests of grain crops, in particular the bread flea. In the conceptual model, the structural approach describes the structures of objects and their relationship. To develop a requirement for the design of a conceptual model, you should first answer a few questions:

1 Why do we need a conceptual model?

2 What will the conceptual model include?

3 What will the conceptual model look like?

Having received answers to these questions, it is possible to build requirements for a conceptual model of an analytical system for predicting the growth of the number of pests of grain crops.

The conceptual model development stage considers the sequence of actions to obtain a forecast of the number of bread flea growth. At the beginning of the project, data are collected from the RSU "Republican Methodological Center for Phytosanitary Diagnostics and Forecasts" on the number of density of striped fleas per m^2 in 8 regions of Kazakhstan. In addition, climatic indicators are obtained from the hydrometeorological center. All the received data is processed and presented in one tabular format (EXCEL databases). An EDA analysis (exploratory data analysis) is carried out, finding patterns in them and correlating between features (data). The result of the EDA analysis is the calculation of statistical values and the identification of the average, maximum, minimum values of all quartiles (25 %, 50 %, 75 %) by all indications. Correlation matrix, dependency graphs. After the EDA analysis, an experiment is conducted to compare the results of using standard forecasting models (linear regression, gradient boosting, random forests, machine learning). Before the experiment, the processed data was normalized. The normalized data will serve as indicators of the input data, on the basis of which a data interaction matrix is created. The data is normalized through the Python StandardScaler library and is called from sklearn. A neural network is selected from standard forecasting models, with the help of which data is trained. After training the data, the result is visualized through an analytical system.

Results and Discussion

Requirements for the design of a conceptual model

The answers to the questions that will help to develop requirements for the design of a conceptual model of an analytical system will be as follows:

1 A conceptual model of the system is needed to visualize the complete picture of the system and the interaction between the objects of the system and to eliminate repetitions and errors in the system.

2 The conceptual model will include all objects and their interaction.

3 The conceptual model will be presented graphically using a UML diagram.

Having answered the questions, you can put forward the following requirements:

1 When defining the objects of the system, take into account the type of objects.

2 The model must include all the intended objects

3 It is necessary to take into account the connections between objects, the action of objects

4 The model must exclude the repetition of the action of the same object

5 The model should eliminate the looping of the process

6 The model must exclude the incompleteness of the algorithm

7 The model must comply with the principles of consistency, consistency and accessibility.

8 The model must be flexible so that blocks can be changed or replaced at any time.

Development of a conceptual model of an analytical system for forecasting a pest of grain crops.

The concept of an analytical system describes what a block should have that trains data every time it is updated. The trained data is stored in the system database. The data is updated with the annual input of new data on the number of bread fleas. There are two ways to enter data manually or automatically. The analytical system provides a forecast for the number of pest growth for the next year, and provides analytical data for the past year. Indicates one or another factor that influenced the numerical growth of pests.

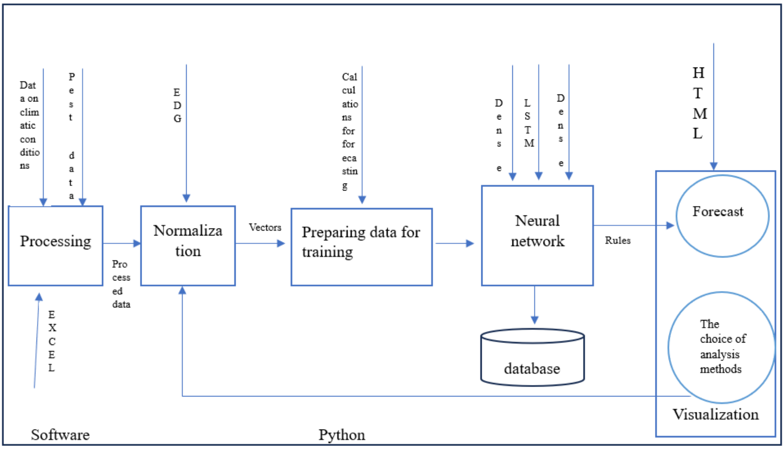

Figure 1 – The conceptual model.

The developed conceptual model (Figure 1) includes 8 interconnected blocks containing descriptions of objects interacting with each other. The conceptual model describes the information flow of data, which shows which objects the analytical system includes. Each object interacts with another object in one way or another and this is clearly reflected in the model. Clarity in the execution of the conceptual model gives a clear idea to developers who will be able to create a full-fledged working system with a user interface based on the model.

The data flow diagram clearly shows the movement of information from one object to another, as well as which object operates within which rule. Data processing requires data on climatic conditions and pests. This data is processed in the normalization block, where it is converted into vectors, for further preparation for training. Preparing data for training consists in performing calculations for forecasting and transmitting them to a neural network. The neural network, based on the established rules, generates a forecast. Then the constructed neural network stores the results in a database and offers a choice of analysis methods. The final stage is the visualization of the forecast and the selected analysis methods.

The development of a conceptual model of an analytical pest forecasting system is an important stage in the design of an analytical system. It is worth noting that the choice of appropriate analysis and modeling methods is crucial for the successful implementation of an analytical system. In this research, a review of the scientific literature of the proposed conceptual models for various systems was conducted, which made it possible to identify optimal approaches to designing a conceptual model for an analytical system for forecasting pests of grain crops in agriculture.

The conceptual model in Figure 1 shows objects interacting with each other in the system. In this conceptual model, all objects and their interaction are clearly and clearly expressed, how data gets into the system and what happens to them, which gives the developer a clear understanding of the sequence of analytical system development, user interface development. The conceptual model was developed with respect to the above requirements, and therefore the model is error-free.

The conceptual model meets all the requirements for the design of modern systems. The sequence of the information flow described in the model indicates the consistency in the organization of the model.

Finally, the proposed model for the pest forecasting system is an important tool for improving the efficiency of developers' labor productivity.

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Conclusion

As mentioned above, the purpose of this research was to develop a conceptual model of an analytical forecasting system for the main pest of grain crops – the bread striped flea (Phyllotreta vittula). As a result, the purpose of the study was achieved and trained data in a neural network for predicting the number of pests was obtained. Accurate and timely identification of the striped bread flea is an important step in increasing yields and ensuring the sustainability of agricultural production. The conceptual model is designed to help farmers mitigate the effects of pest attacks. The proposed model represents a practical way to predict the dynamics of the pest population.

In the design methodology, the entire development process is divided into three main phases: conceptual, logical and physical design. In this study, a conceptual model of an analytical system for predicting the number of pests of grain crops was presented.

In the future, the results of this study can be applied at the next stage of the development of an analytical system for forecasting and managing the number of pests in agriculture.

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АУЫЛ ШАРУАШЫЛЫҒЫНДАҒЫ БОЛЖАУ ПРОЦЕСІН АВТОМАТТАНДЫРАТЫН АНАЛИТИКАЛЫҚ ЖҮЙЕНІҢ ТҰЖЫРЫМДАМАЛЫҚ МОДЕЛІН ЖОБАЛАУ

Пәндік саланы зерттеу және тұжырымдамалық модель құру кез-келген жүйені дамытудағы маңызды қадамдар болып табылады, өйткені олар жүйенің талаптарын, функционалдығы мен құрылымын анықтауға және оны жүзеге асырмас бұрын жобаның жалпы көзқарасын орнатуға көмектеседі. Ауыл шаруашылығын автоматтандыру зиянкестер санының өсуін болжау үшін аналитикалық жүйелерді әзірлеуді талап етеді, бұл өз кезегінде тақырыптық саланы зерттеуді және аналитикалық жүйе үшін тұжырымдамалық модельді ұсынуды қамтиды. Бұл мәселені шешу ауыл шаруашылығы саласындағы ғалымдардың дәнді дақылдардың зиянкестерін анықтау санының өсуін есептеу және болжау кезіндегі жұмысын автоматтандыруға көмектеседі.

Әр түрлі қызмет салаларындағы, әсіресе ауыл шаруашылығы секторындағы қолданыстағы тұжырымдамалық модельдерге шолу жасалды. Жүйенің жоғары тиімділігі мен сенімділігін қамтамасыз ететін жүйеге қойылатын талаптар қойылды.

Объектілер мен олардың өзара байланысын қамтитын дәнді дақылдардың зиянкестерін болжауға арналған аналитикалық жүйенің тұжырымдамалық моделі ұсынылған. Тұжырымдамалық модель жүйенің алгоритмдері мен принциптерін қамтиды.

Кілтті сөздер: тұжырымдамалық модель, аналитикалық жүйе, болжау, ауыл шаруашылығы, зиянкестер, жолақты нан бүргесі.

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ПРОЕКТИРОВАНИЕ КОНЦЕПТУАЛЬНОЙ МОДЕЛИ АНАЛИТИЧЕСКОЙ СИСТЕМЫ АВТОМАТИЗИРУЮЩЕЙ ПРОЦЕСС ПРОГНОЗИРОВАНИЯ В СЕЛЬСКОМ ХОЗЯЙСТВЕ

Изучение предметной области и создание концептуальной модели являются важными шагами в разработке любой системы, поскольку они помогают определить требования, функциональность и структуру системы, а также установить общее видение проекта перед его реализацией. Автоматизация сельского хозяйства требует разработки аналитических систем для прогнозирования роста численности вредителей, которая в свою очередь предполагает изучение предметной области и представления концептуальной модели для аналитической системы. Решение данной проблемы поможет автоматизировать работу ученых в области сельского хозяйства при расчете и прогнозе роста численности выявления вредителя зерновых культур.

Проведен обзор существующих концептуальных моделей во разных сферах деятельности, в особенности в *сельскохозяйственном секторе. Выдвинуты требования к системе, обеспечивающие высокую эффективность и надежность системы.*

Представлена концептуальная модель аналитической системы для прогнозирования вредителя зерновых культур, которая включает объекты и их взаимосвязь между собой. Концептуальная модель включает алгоритмы и принципы работу системы.

Ключевые слова: концептуальная модель, аналитическая система, прогнозирование, сельское хозяйство, вредители, хлебная полосатая блошка.

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