Information and Technological Support for the Processes of Prognostic Modeling of Regional Labor Markets

Yuri Romanenkov[1][0000-0002-3526-7237], Volodymyr Pasichnyk[2][0000-0003-3007-2462], Nataliia Veretennikova[2][0000-0001-9564-4084], Mariia Nazaruk[3][0000-0001-7459-4911], Andrii Leheza[4][0000-0002-8892-2426]

[1]Management department, National Aerospace University – Kharkiv Aviation Institute, Kharkiv, Ukraine
[2]Information Systems and Networks Department, Lviv Polytechnic National University, Lviv, Ukraine
[3]Informatics and Applied Mathematics Department, State Humanitarian University, Rivne, Ukraine
[4]Software Supply Systems Department, Uzhhorod National University, Ukraine

KhAI.management@ukr.net, vpasichnyk@gmail.com, nataver19@gmail.com, marinazaruk@gmail.com, andrewlegeza@gmail.com

Abstract. The process of selecting a profession in accordance with the needs of the individual and the requirements of the city's labor market is a complex, multi-step, iterative process that requires consideration of a large number of parameters and prerequisites. The determination of professional inclinations is based on the analysis of the accumulated results of vocational guidance tests that help to identify human abilities in a certain field of activity and allow you to choose a branch of professional activity. Labor market monitoring is in order to identify trends in factors affecting the supply and demand of work in the city. Determining the development prospects requires a convenient tool for assessing trends in the volatility of the demand for the regional labor market, which is carried out in several stages, consisting of the processes of collecting, verifying and accumulating statistical information by the key coordinates of the phase space; forming a group of basic methods for predicting the lower level, suitable for working with time series, taking into account their features (stationary, omission, noises, etc.); development of an adequate model of adaptive integration of forecast estimates from different sources; support of the interactive mode of parametric adjustment both for the forecasting models of the lower level and the model of complexation.

Keywords: forecasting support, professional choice, professional inclinations, forecasting, information modeling, vocational guidance tests.

1 Introduction

The level of development of modern information technologies and communication systems [1] contributes to the continuous growth of various data types of monitoring organizational technical social and economic systems, which are accumulated in specialized databases as well as in the form of time series. These data reflect the dynamics of multifactorial processes, reflecting all the nuances of their specific causes, factors and connections. In this case, data accumulated may be uncertain [2-4], which is due to methods and means of monitoring, as well as observer's subjectivity.

1.1 Analysis of the Research State

Formalization of the functioning conditions of a complex social and economic object, particularly quantitative indicators of its external and internal environment [5], allows us to determine the position of an object in a competitive social and economic environment. A set of these indicators allows you to form a phase space and determine the changes in the life cycle of an object [6].

This approach contributes to the formation of predictive estimates of coordinate values, phase space for effective strategic analysis [7].

An example of such complex objects is an educational social and communication environment of a large city that is a multidimensional and polyfunctional complex system that functions and develops in real time in a defined territorial space (real or virtual one) whose activities are managed and coordinated as well as pedagogical influence of objective and subjective factors on subjects of educational process is implemented.

Several researchers suggest using information technologies and information systems to help automate the process of choosing a profession by smart city residents. There is practically no opportunity in one information point to analyze information about a person as an object of vocational guidance and educational work and to obtain comprehensive information and analytical data of the regional labor market and educational services. Information is mainly provided without proper authenticity and structuring.

Certain technological developments are in the context of choosing a particular specialty while entering a higher education institution. In a number of papers, it is suggested to use the modular principle when developing a recommender system that facilitates the implementation process of choosing a specialty in a particular institution.

2 Information Technology Analysis of the IT Labor Market

The information sources about the professional orientation of the World Wide Web are divided into integrated and independent web pages.

Integrated web pages are the pages of professional counseling organizations and institutions. They contain both general and specific information for this institution. As a rule, their use is free of charge.

Independent web pages are non-interlinked pages that include information about vacancies, professions, educational positions of schools and higher education institutions, work offers with the description of an enterprise, as well as they also provide assistance with decision-making on choosing a future profession or changing it.

According to the functional purpose, information technologies focused on providing solutions to the problems of professional orientation of young people, can be conditionally divided into the following classes [8]:

Sites of educational institutions that inform about the admission conditions and training directions, are aimed at encouraging graduates to enter this or that higher educational institution. Such resources are not oriented to maintain the processes of an individual profession choice, do not give substantiated advice to an entrant, but, instead, create uncertainty about the profession, as a young person is hesitant about several equal or similar options for choosing a possible specialty.

Educational portals. This type includes resources that contain comprehensive information about all aspects that relate to education in general. However, such sites do not contain clear advice for people who choose a profession, do not provide objective testing for the subject of professional orientation, which would help to consider the individual abilities choosing a specialty, an inclination for a certain activity type, psychophysical abilities of a young person, regional aspects, etc.

Employment resources. This type of Internet resources is the most popular among similar tools. As a rule, they can help you to get information about the list of vacancies, their features and additional requirements, the availability of vacancies in different regions, as well as to contact an employer. The disadvantage of such IT is the lack of information on educational institutions, where it is possible to obtain the relevant profession, requalify or get the second higher education.

Test resources. This type of IT offers a good selection of different psychological tests that relate to the choice of profession. As a rule, their main disadvantage is that they do not contain information on the further orientation of a profession searcher, especially about educational institutions, aspects of the profession, prospects for employment, the need for a profession in our time, and so on.

The comparison results of the functional characteristics of the existing legal and national online resources of professional orientation are shown in Table 1 ("+" indicates the functions implemented by the system, "-" – not implemented, "+ /" – implemented partly). The analysis was conducted using the following parameters:

P1 is to definite professional inclinations and abilities of a person;

P2 is to inform the searcher about profession and its characteristics;

P3 is to inform about the educational service market;

P4 is the labor market monitoring;

P5 is to provide personalized recommendations on the profession choice according to personal inclinations and labor market needs;

P6 is the formation of an individual learning trajectory.

Table 1. Online resources of professional orientation

Country	Name	Functional characteristics						Web-adress
		P_1	P_2	P_3	P_4	P_5	P_6	
The USA	SC Accelerate	-	+	+	+	+	-	*http://scaccelerate.com/*
	Hobsons	+	+	-	+	+	+/-	*https://www.hobsons.com/*
	What Career is Right for me	+	+	+	+	+/-	-	*https://www.whatcareerisright-forme.com/*
	American Job Center Network	+/-	+	+	+/-	+/-	-	*https://www.onetonline.org/*
India	"Ektishaf" Programme	+	+	+/-	+	+	+/-	*http://www.iktshaf.com/index.php*
Canada	Career Choice GPS	+	+	+/-	+	+	+/-	*https://www.careerchoicegps.com/*
Australia	The Good Universities Guide	+	+	+	+	+/-	+/-	*https://www.gooduniversities-guide.com.au/*
Poland	Mapa karier	-	+	+	+	-	-	*https://mapakarier.org/*
	Infopraca	+	+	+	+	+/-	+/-	*http://kariera.infopraca.pl*
Russia	Enter online	+	+	+	+/-	+/-	+/-	*https://postupi.online/*
	Smartia	+	+	-	-	+/-	-	*https://smartia.me/*
	My education	+	+	+	-	+/-	+/-	*https://moeobrazovanie.ru*
Byelorussia	Proforientation	+	+	-	-	-	+/-	*http://proforient.ucoz.ru*
Ukraine	Kariera	+	+/-	+/-	+	-	-	*http://kariera.in.ua/*
	Education.ua	-	+	+	-	-	+/-	*https://www.education.ua*
	My career	+	+/-	+/-	+	-	-	*http://mycareer.org.ua*
	Education.UA	-	+	+	-	-	-	*http://osvita.ua/*
	Internet project "Proforientation"	+	+	+	-	-	-	*http://prof.osvita.org.ua*

The analysis showed that well-known information technologies and Internet resources are specialized and focused on solving only a part of the problems that arise in the process of choosing a professional orientation.

Considering the fact that the risk measure in case of wrong planning is sufficiently significant, the information and technological support for training specialists seems to be an urgent task, i.e. the system creation of interconnected information technologies designed to reduce labor-capacity and improve the task quality for the organization of specialist training. Obviously, the prognostic support of such systems should be based on the methodology of scientific forecast, while at the same time characterized by a possibility of interactive adjustment and adaptation [9].

3 Scientific Forecasting of Labor Market Needs

The relevance of predictive support can be argued by the fact that the Nobel Prize in 2013 was received by American economists on the basis of research in the prognostic field.

In the paper [10] it is written that "the activity of social and economic systems generates a variety of methods for forecasting". In modern publications of researchers, particularly, it is mentioned that "... more than 100 methods of forecasting are counted, and the experts are faced with the task of choosing methods that would implement adequate forecasts for investigated subject areas".

An adequate amount of data obtained during the research provides a high accuracy of forecasting, creation of effective methods and models [11]. The prognostic function is an important component of information support of management processes. For example, it is considered the management models that implement the prognostic support function [12-16].

Prognostic support is one of the key elements of predictive analytics systems. Its results are the information basis for users, and, consequently, should be characterized by accuracy, reliability, stability [17].

The option of providing a full spectrum of methods and means of prognosis in solving management tasks through the synthesis of specialized forecasting information complexes considering the available means of Data Mining is promising under existing conditions.

It means the development of a forecasting support model, as well as the construction of a trajectory of forecasting research, namely the development or selection of methods for setting up the lower-level models and the synthesis of an adaptive model for the compilation of predictive estimates at the upper level [18, 19]. At present there is practically no comprehensive system that would implement forecasting methods to meet the needs of organizations in the predictive support [20].

Specialized forecasting centers, having a modern methodological base and access to the sector monitoring bases, are forced to solve periodically the problem of choosing forecasting model and consolidating forecasts [21, 22].

However, it should be considered that forecasts are useful for planning only if the forecasting components are well thought out and the limitations contained in the forecast are frankly named. It is required [23]:

- to determine the required accuracy of the forecast, based on what decisions are to be taken on its basis;

- to identify the changes that must take place so that the forecast turns out to be truthful; to assess the probability of the relevant event occurrence;

- to determine the forecast components and take care of data sources;

- to determine how valuable the experience preparing the forecast is, whether there are grounds for drawing up a forecast based on this experience, how simple or inexpensive it will be to obtain reliable information about the experience of the past;

- to distinguish how structured the forecast should be.

Thus, the overall logical sequence of forecasting development is reduced to the following main stages (Fig. 1):

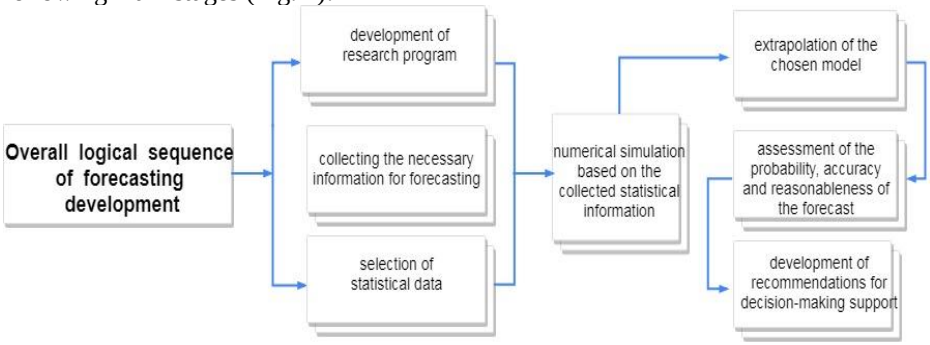

Fig.1. The main stages of the forecast development

Stage 1 is the development of the research program (the goals and tasks of forecasting are formulated; the task for forecasting, nature, scale, object, warning period and forecast horizon are specified; the methods, structure and organization of the research are determined).

Stage 2 is collecting the necessary information for forecasting; reliable statistical information about the studied system is required for the development of a forecasting model;

Stage 3 is the selection of statistical data, their consolidation, verification of probability for ensuring accuracy of forecasting, system analysis and generalization;

Stage 4 is numerical simulation based on the collected statistical information (the prototype creation of a predictive model that most closely matches the characteristics of the collected data and can provide a minimum prognostic error, model evaluation and diagnostic testing);

Stage 5 is an extrapolation of the selected model (involves the actual reception of the required forecast);

Stage 6 is an estimation of reliability and accuracy, as well as validity (verification) of the forecast. The estimation of the received forecast consists in comparison of the calculated values with the values that can be observed. For this purpose, a part of the most recent actual information is usually excluded from the data set that is being analyzed, and prediction is used for recent past periods for which the studied values are already known. If the results coincide, there are reasons to be more confident that the probability level of the forecast is high, if not it is necessary to search and eliminate the problems or drawbacks in the methodology for developing the forecast;

Stage 7 is the development of recommendations for decision-making in the field of management.

Regardless of the forecast type, the main task of forecasting is to show the links between the past and the future, between the information about the process in the controlled time period and the nature of process further, and the most accurate description of these relationships. The fulfillment of this task ensures achievement of the main goal of forecasting, namely the reduction of the uncertainty level in which the leader must make decisions, obtain scientifically substantiated variants of development trends or change in the indicators of the controlled object state in time and space, drawing up a sufficiently accurate, practical, balanced and useful prognosis that can be effectively used in management, and its benefit will exceed the cost of its development.

4 Modern Approaches to Building a Forecasting Model

A general iterative approach to constructing a prediction model consists of the following steps [24]:

Step 1. Choose a general class of models based on previous own or third-party experience to predict time series at a given interval.

Step 2. The rough methods of identifying the model subclasses are applied for the immediate application to the original time series. Such identification methods are based on qualitative estimates of time series.

Step 3. Determine the model subclass and evaluate its parameters (if the model contains parameters) or structure (if the model belongs to the category of structured models). At this stage, iterative methods are usually used when evaluating the segment or the entire time series at different meanings of the variables. As a rule, this step is the most labor-intensive due to the fact that all available historical values of the time series are often taken into account.

Step 4. Carry out a diagnostic checkup of the received forecasting model. One or several segments of time series are selected more often, which are sufficient in length for verification prediction and the next estimate of the forecast accuracy. Selected prediction models of time series segment for diagnostics are called control segments (periods).

Step 5. If the accuracy of the diagnostic prediction is acceptable for tasks using predictive values, than the model is ready for use. In case that the prediction accuracy is not sufficient for the next use of predictive values, it is possible to repeat iteratively all the steps described above, starting with the first one.

We formulate the main tasks of the forecasting support of the model of regional labor market on the example of the IT industry:

1) collection, verification and accumulation of statistical information from the key coordinates of the phase space for the model of the regional labor market of the IT industry;

2) make of a group of basic methods of forecasting the lower level, suitable for working with time series, taking into account their features (stationary, omissions, noise, etc.);

3) making of an adequate model of adaptive integration of forecast estimates of the labor market of the IT industry;

4) support of interactive mode of parametric adjustment, both predictive models of the lower level and integration model, which allows a reasonable intervention of the subject of management.

It is proposed to provide multi-layer prognostic support, which is consisted of several levels [25].

At the first level, there are statistical forecasting models. Information technology forms a proven set of predictive models and methods specific to its prognostic activity. For example, studying the dynamic processes along with traditional methods, the new methods are more and more applicable and, in particular, a popular method of analysis and forecasting of time series called caterpillar SSA [26-29]. It should be distinguished its qualities which:

- allows you to decompose the output series into a trend, periodic and noise components without defining a model;
- gives an opportunity to study both stationary and non-stationary time series;
- allows you to investigate the structure of a time series, to allocate its separate simple components and to interactively predict the tendency of development of both the series itself and its terms [29];
- is effective for the analysis and forecasting of processes that allow the decomposition into polynomial, exponential, and periodic components in the background of noise;
- can be applied to modulated harmonics, which advantageously differs from methods based on the Fourier method;
- provides an ability to select control parameters (row length, length of time, number of components) for better separation of components of the series;
- the results of the method are stable both to the choice of the length of the caterpillar, and to the choice of the variant of the method;
- is interactive with an ability to interpret intermediate visual results and analyzing information about the structure of the investigated process and the properties of its components, as well as an ability to control the operation of the algorithm in the process of multi-stage data processing of data.

The SSA method has a very wide scope of application, is relatively simple to manage, it is natural, powerful, distinguished by the visibility, but it remains low-income in applications.

At the second level, there are models that are called selective predictive models, aggregated on the basis of solution rules.

At the next level, there are combined forecasting models [30] that involve structural and parametric exchanges in order to parry the natural disadvantages of the base models.

At the fourth logical level of the model, there are models of forecasting estimation and the consolidated forecasts can be synthesized using multiple sources.

5 Conclusions

The research confirms that forecasting, regardless of the used concrete tools of forecasting at the lower level, is provided by top-level models (complex forecasting estimation) that can guarantee satisfactory quality of forecasting support, namely, the accuracy of adaptive predictive support of the regional labor market model of the IT industry.

Thus, by developing the information technology of estimating vacancies on the labor market, it is suggested to use prognostic technology, which allows predicting the development of the labor market in a particular industry. The research is conducted using data from the IT industry and further research provides the creation of a comprehensive model of this industry and development prospects.

References

1. Yavuz, H., Bradshaw, A.: A New Conceptual Approach to the Design of Hybrid Control Architecture for Autonomous Mobile Robots. Journal of Intelligent and Robotic Systems, Vol. 34, Issue 1, 1–26 (2002).
2. Ruban, I., Volk, M., Filimonchuk, T., Risukhin, M., Romanenkov, Y.: The Method for Ensuring the Survivability of Distributed Computing in Heterogeneous Computer Systems. Proceedings International Scientific-Practical Conference on Problems of Infocommunications Science and Technology (2018).
3. Jeffery, S., McMullen, Dean, A.: Shepherd: Entrepreneurial Action and the Role of Uncertainty in the Theory of the Entrepreneur. The Academy of Management Review, Vol. 31, No. 1, 132-152 (2006).
4. Gaydabrus, B.V., Druzhinin, E.A., Kiyko, S.G.: Main aspects of project management and development programs of IT availability of the manufacturing enterprises. Metallurgical and Mining Industry, № 12, 326–330 (2015).
5. Robert S. Kaplan: Conceptual Foundations of the Balanced Scorecard. Working Paper, Elsevier, 210 (2009).
6. Clive Altshuler Dawn, Pingfan, H., Hong Hung-Yi, Li: The World Economic Forecasting Model at the United Nations (2016).
7. Stephen, A.: Weiswasser: Role of Technology in Communication. Fordham International Law Journal, Volume 21, Issue 2, (1997).
8. Kovaliuk, T., Pasichnyk, V., Veretennikova, N., Kunanets, N.: Professional competency man-agement of IT professionals to industry requirements based on cognitive cards. Information Technologies and Learning Tools, Vol 64, No 2, 253-264 (2018).
9. Jun, Su, Lytvyn, V., Vysotska, V., Sachenko, A., Dosyn, D.: Model of Touristic Information Resources Integration According to User Needs. 13-th International Scientific and Technical Conference on Computer Science and Information Technologies (CSIT), 113-116 (2018).
10. Bomba, A., Kunanets, N., Nazaruk, M., Pasichnyk, V., Veretennikova, N.: Information technologies of modeling processes for preparation of professionals in smart cities. Advances in Intelligent Systems and Computing, Vol. 754, 702-712 (2018).
11. Nota, Laura, Sara, Santilli, Salvatore, Soresi: A Life-Design-Based Online Career Intervention for Early Adolescents: Description and Initial Analysis. The Career Development Quarterly, 64.1, 4-19 (2016).

12. Ceschi, Andrea, et al.: The career decision-making competence: a new construct for the career realm. European Journal of Training and Development, 41.1, 8-27 (2017).
13. Lytvyn, V., Pukach, P., Bobyk, I., Vysotska, V.: The method of formation of the status of personality understanding based on the content analysis. In: Eastern-European Journal of Enterprise Technologies, 5/2(83), 4-12 (2016)
14. Gorbachov, V., Batiaa, A. K., Ponomarenko, O., Romanenkov, Y.: Formal transformations of structural models of complex network systems. Proceedings of IEEE 9th International Conference on Dependable Systems, Services and Technologies (2018) https://ieeexplore.ieee.org/document/8409175
15. Lytvyn, V., Vysotska, V., Lozynska, O., Oborska, O., Dosyn, D.: Methods of Building Intelligent Decision Support Systems Based on Adaptive Ontology. Proceedings of the 2018 IEEE 2nd International Conference on Data Stream Mining and Processing, DSMP, 145-150 (2018).
16. Lytvyn, V., Peleshchak, I., Vysotska, V., Peleshchak, R.: Satellite spectral information recognition based on the synthesis of modified dynamic neural networks and holographic data processing techniques, 2018 IEEE 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2018 – Proceedings 1, 330-334 (2018).
17. Armstrong, J. S., Brodie, R. J.: Forecasting for Marketing (1999). http://repository.upenn.edu/marketing_papers/
18. Chen, K.-Y.: Combining linear and nonlinear model in forecasting tourism demand. Expert Syst. Appl., № 38, 10368–10376 (2011).
19. William, A.Branch, Georg,e W.Evans: A simple recursive forecasting model. Economics Letters, Volume 91, Issue 2, 158-166 (2006).
20. Matijaš, M., Suykens, J.A., Krajcar, S.: Load Forecasting using a Multivariate Meta-Learning System. Expert Systems with Applications, Vol. 40, № 11, 4427-4437 (2013).
21. Nai-mingXie, Si-fengLiu: Discrete grey forecasting model and its optimization. Applied Mathematical Modelling, Volume 33, Issue 2, 1173-1186 (2009).
22. Dahl, C. M., et al.: The cyclical component factor model. International Journal of Forecasting (2008).
23. Wang-Chuan Juang: Application of time series analysis in modelling and forecasting emergency department visits in a medical centre in Southern Taiwan. BMJ Open. 7(11) (2017).
24. Romanenkov, Yu., Vartanian, V.: Formation of prognostic software support strategic decision-making in an organization. Eastern-European Journal of Enterprise Technologies, Vol. 2, No. 9 (80), 25-34 (2016) (DOI: 10.15587/1729-4061.2016.66306).
25. Kiyko, S.G., Druzhinin, E.A., Koba, S.A., Haidabrus, B.V.: A mathematical background for information technology of project's processes integration taking into account risk factors. Metallurgical and Mining Industry, 6(3), 66-70 (2014).
26. Golyandina, N.E., Osipov, E.: The “Caterpillar”- SSA method for analysis of time series with missing values. Journal of Statistical Planning and Inference, Vol. 137, Issue 8, 2642-2653 (2007).
27. Priestley, M. B.: Non-Linear Models in Time Series Analysis. Journal of the Royal Statistical Society. Series D (The Statistician) Vol. 27, No. 3/4, 159-176.
28. Lytvyn, V., Vysotska, V., Peleshchak, I., Rishnyak, I., Peleshchak, R.: Time Dependence of the Output Signal Morphology for Nonlinear Oscillator Neuron Based on Van der Pol Model. In: International Journal of Intelligent Systems and Applications, 10, 8-17 (2018)

29. Stepanov, D. V., Golyandina, N.E.: SSA-based approaches to analysis and forecast of multidimensional time series. Proc. of the 5th St. Petersburg Workshop on Simulation, St.-Petersburg, 293–298 (2005).
30. Kut, V., Kunanets, N., Pasichnik, V., Tomashevskyi, V.: The procedures for the selection of knowledge representation methods in the “virtual university” distance learning system. Advances in Intelligent Systems and Computing, Volume 754, 713-72 (2019)