Smart Control System of Human Resources Potential of the Region

Olga A. Ivashchuk, Igor S. Konstantinov and Irina V. Udovenko

Abstract In this paper we present the results of our research and modeling of the Smart Control System for the human resources potential of the region (SCS of HRP) which has to become an integral part of the general intellectual network of management of the Smart City functions. We construct the conceptual model of human resources potential as an object of automated control. As a result the object of control is considered as a complicated dynamic informational, social and economic system. We develop the generalized structural model of SCS of HRP, which is endowed with both traditional functions of collecting and processing information and functions of intellectual analysis of data based on situational and mathematical modeling of the process of interaction of components of human resources potential between each other and environment. This approach provides the possibility of adaptive balanced management as well as development of rational productive managing decisions.

Keywords Smart control system · Human resources · Modeling

1 Introduction

The level of social and economic as well as scientific and technical development of regions of a modern state is considerably defined by not only available raw and material and technical base, but also by the condition of their human resources potential, which the competitiveness of enterprises and organizations as well as the

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effect of investments into region economy, the result of introduction of innovations, the development of services sector depend on.

In this paper we will consider the term "human resources potential of the region" (HRP) as the complex of: formed and constantly developing professional knowledge and skills of the available human resources of a region (including the registered in an employment office); accumulated knowledge and skills of future human resources, who are students of educational professional institutions now; as well as a future knowledge, skills and abilities of minor part of the population of a region.

In the conditions of the innovation-focused development of economy formation of HRP is characterized by the following key features:

- all the above-stated structural components of HRP as well as the factors, which influence them directly, for example, a demographic situation, a condition of modern educational services and regional labor markets, are changing continuously;
- the processes of their interaction between each other and environment are characterized by high dynamics and complexity;
- the level of state regulation is extremely low in the field.

Many researchers consider a problem of the balanced development of the countries and regions on the basis of effective management of their personnel potential with the relevant decision of tasks of overcoming of a disproportion between the markets of workplaces and labor. However the following approaches are generally used:

- the formation of an active state policy [2, 6, 7];
- the formation of the optimal structure of the business community [1, 3–5, 9, 10];
- improvement of the educational processes in institutions of professional education [8].

At the same time, the general methodological approach to building effective management systems which will be adaptable to changes in the HRP (a control object) and in the external environment, as well as an instrumental mechanism to ensure the functioning of such systems to date have not been established.

It should be noted that the effectiveness of control processes such complex dynamic objects as HRP, connected with the necessity of collecting and processing large volume of heterogeneous information, creation and implementation of predictive models. Thus, for the creation of such control systems, it is necessary to use IT, technologies of automation, advanced methods of situational and mathematical modeling. This direction, as shown by various studies [4], is at an early stage of development.

The authors set the task to model a Smart Control System for the human resources potential of the region (SCS of HRP) which has to meet the following main requirements:

- to provide the process of effective and productive control of human resources potential in various spheres of economy,

– to be universal for any level of hierarchy of administrative and territorial division,
– to be adaptive to current changes in social and economic sphere on the considered territory as well as in environment.

2 Modeling of the HRP as Object of Smart Control

The analysis of interaction between HRP and social and economic and environment of the regions was carried out; it allowed us to determine its state parameters as a modeled operated system, to distinguish controlled and operated ones from them as well as to define the borders of this system with the environment. As a result we constructed a conceptual model of HRP as an object of automated control, which is not considered as a traditional "black box", but as a multicomponent system with concrete structure and information flows reflecting interaction of its systems between each other and between its systems and environment. Schematically this model is shown in Fig. 1.

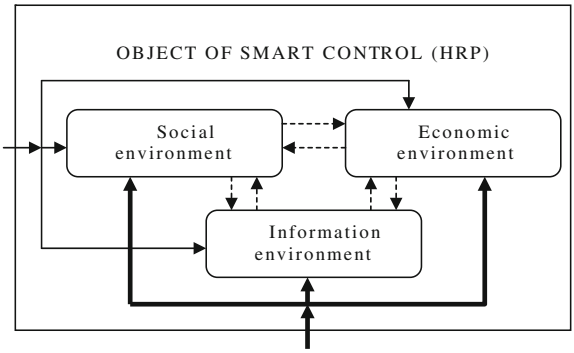

Fig. 1 HRP model as an object of Smart control

The system includes the following three main classes of components: system "Social environment"; system "Economic environment"; system "Information environment". Thus, HRP is presented as a complex dynamic information-social-economic system. On the scheme the dashed lines show the flows reflecting the interaction of the main systems of the object of control between themselves; the continuous thin lines – influence of environment; continuous bold lines – control actions directed at the main systems.

The example of the corresponding classification of the parameters of the state of the object of control (its main components) is shown in Fig. 2. More concrete structure of the considered controlled system, classification of the parameters of the state and the corresponding mechanisms of control of HRP depend on the specifics

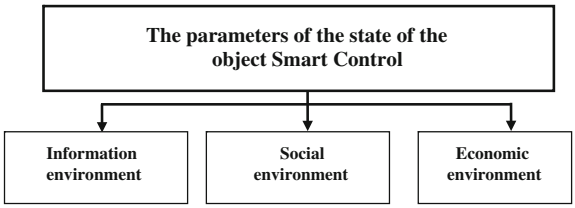

Fig. 2 The parameters defining the state of the human resources potential of the region, as an object of smart control

of the region and features of those branches of economy, which are priority for this territory.

For example, consider the parameters of the information environment:

- parameters connected with structuration and completeness of the contents of labor markets and educational services of the region;
- availability and quality of the information environment integrated with other regions;
- number of students using distance learning;
- parameters of the technology of public opinion forming;
- number of available PC to access to the Internet;
- number and availability of radio-, TV centers in Institutions of Higher Education.

3 Functions of Smart Control System

As a result of functioning of the modeled SCS of HRP the steady state of the latter in the conditions of environment influence *(realization of the objective of the system functioning)* has to be achieved; in this case at any moment quantitative and qualitative parameters of the labor force of the region have to be the most closely resembling the demanded target state *(realization of the main objective of the human resources policy)* that corresponds to the sustainable innovation-focused development of the region, its competitiveness *(realization of the main objective of social and economic development of the region)*. Further specification of the purpose of the system (objectives tree derivation) and the corresponding systematization of ways of its achievement (systems tree derivation) allow us to reveal the main systems, the processes of their interrelated functioning.

The main functions of the SCS of HRP and the corresponding systems realizing these functions are presented schematically in Fig. 3.

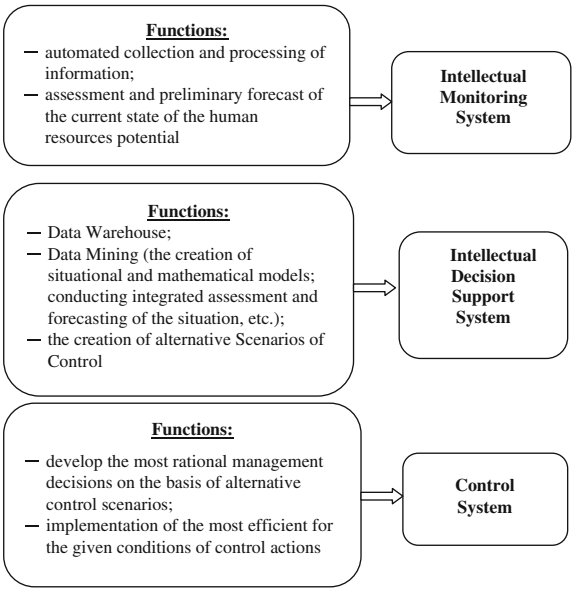

Fig. 3 The main functions of the smart control system of HRP and its the subsystems

4 Structural Model of the Smart Control System

From the point of view of the set-theoretic approach the model of the system of the considered class can be presented by the following way:

$$S_{SCS} = \langle \Sigma_{SCS}, X_{SCS}, Y_{SCS}, Z_{SCS}, \Omega_{SCS}, F_{SCS}, \Theta_{SCS} \rangle, \quad (1)$$

where $\boldsymbol{\Sigma}_{SCS}$ – set of components-systems of SCS;
$\boldsymbol{X}_{SCS}$ – set of states of elements (entrances)$\boldsymbol{\Sigma}_{SCS;}$
$\boldsymbol{Y}_{SCS}$ – set of states of elements (exits) $\boldsymbol{\Sigma}_{SCS;}$
$\boldsymbol{Z}_{SCS}$ – set of states of systems $\boldsymbol{\Sigma}_{SCS;}$
$\boldsymbol{\Omega}_{SCS}$ – set of influences of environment on $\boldsymbol{\Sigma}_{SCS;}$
$\boldsymbol{F}_{SCS}$ – set of the displays carried out on $\boldsymbol{\Sigma}_{SCS,}$ $\boldsymbol{\Omega}_{SCS}$ and $\boldsymbol{Y}_{SCS;}$
$\boldsymbol{\Theta}_{OC}$ – set of the relations over elements $\boldsymbol{\Sigma}_{SCS,}$ $\boldsymbol{\Omega}_{SCS}$ and $\boldsymbol{Y}_{SCS;}$

According to the scheme of the figure $\boldsymbol{\Sigma}_{SCS} = \{\boldsymbol{S}_{OC}, \boldsymbol{S}_{CS}, \boldsymbol{S}_{IM}, \boldsymbol{S}_{IS}\}$, where $\boldsymbol{S}_{OC}$–*object of SCS*;

$\boldsymbol{S}_{CS}$–*Control System*; $\boldsymbol{S}_{IM}$ – *Intellectual Monitoring System;* $\boldsymbol{S}_{IS}$– *Intellectual Decision Support System* (IDSS). Respectively, the set of states of components of SCS of HRP can be presented in the form $\boldsymbol{Y}_{SCS} = \{\boldsymbol{Y}_{OC}, \boldsymbol{Y}_{CS}, \boldsymbol{Y}_{IM}, \boldsymbol{Y}_{IS}\}$; set of influences of environment $\boldsymbol{\Omega}_{SCS} = \{\boldsymbol{\Omega}_{OC}, \boldsymbol{\Omega}_{CS}, \boldsymbol{\Omega}_{IM}, \boldsymbol{\Omega}_{IS}\}$.

The structural model of SCS of HRP is schematically presented in Fig. 4. During its construction the approaches stated in [11–13] were used.

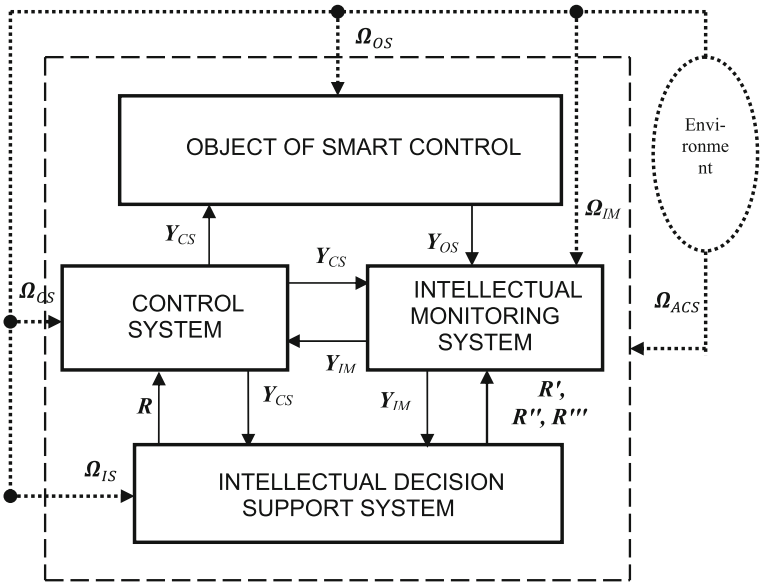

Fig. 4 The structural model of SCS of HRP

It should be noted that the components of set $\boldsymbol{Y}_{IS}$ are controlling signals both for the object of control of SCS, and for the control system itself as well as for the system of intellectual monitoring. They regulate the work of these components of SCS according to the current changes in the object of control and environment.

Thus, the inputted system of IDSS provides formation of internal contours of control in the SCS of HRP, in each contour there is an internal subject of control – IDSS, and internal objects of control – either a control system or a system of intellectual monitoring. The inputted contours provide the possibility of self-adjustment of the system that corresponds to the principle of adaptability in HRP control. The set $\boldsymbol{Y}_{IS}$ includes the following $\boldsymbol{Y}_{IS}$ components $= \{\boldsymbol{R}, \boldsymbol{R}', \boldsymbol{R}'', \boldsymbol{R}'''\}$, where $\boldsymbol{R}$ – a set of alternative scenarios of control to regulate the state of the object of control, $\boldsymbol{R}'$ – a set of models to carry out assessments of different levels (the state of the components of the object of control and intellectual system of monitoring, the productivity of the managing influences, etc.), $\boldsymbol{R}''$ – a set of forecast models, $\boldsymbol{R}'''$ – a set of the influences regulating the structure of the system of intellectual monitoring. The controlling signals coming from ISSDM in the course of internal control are formed as a result of the following displays:

$\boldsymbol{f}_{IS}: \boldsymbol{\Omega}_{IS} \times \boldsymbol{Y}_{CS} \times \boldsymbol{Y}_{IM} \rightarrow \boldsymbol{R}$ – formation of alternative scenarios of control to regulate the work of the control system of SCS of HRP;

$\boldsymbol{f}'_{IS}: \boldsymbol{\Omega}_{IS} \times \boldsymbol{Y}_{CS} \times \boldsymbol{Y}_{IM} \rightarrow \boldsymbol{R}'$ – formation of models for to estimate and regulate the structure of the intellectual monitoring system and the parameters of monitoring, to estimate the current state of HRP;

$f''_{IS}: \Omega_{IS} \times Y_{CS} \times Y_{IM} \to R''$ –formation of models for preliminary forecasting of any change of the current state of HRP;

$f'''_{IS}: \Omega_{IS} \times Y_{CS} \times Y_{IM} \to R'''$ – formation of the control influences to regulate the structure of the system of intellectual monitoring.

Specified in the generalized SCS model sets are filled with concrete contents depending on the tasks being solved in the field of the balanced management of HRP as well as the features of social and economic development of the territory.

5 Modeling of Intellectual Monitoring System and Intellectual Decision Support System

To choose and carry out concrete rational actions for the qualitative and quantitative balanced regulation of HRP the control system has to have, firstly, reliable information about the current state of the object of control, and, secondly, rather full set of alternative scenarios of control created on the basis of demographic, production, social and financial forecasts. These problems are solved at the level of the introduced above specialized intellectual systems of SCS of HRP: the Intellectual Monitoring System and the Intellectual Decision Support System.

Specification of the structure of the intellectual monitoring system is shown in Fig. 5. Its main components: a system of information collecting (about the parameters of all elements of the object of control, the control system and IDSS as well as about the parameters of the controlled external influences); the system of assessment of the current state of the object of control; the system of the preliminary forecast of the current state change of the object of control. The last two systems are the ones, which provide intellectualization of the monitoring system and for their effective functioning it is required to use specially developed situational and mathematical models (the controlling signals R' and R''). Besides, the structure of the system of intellectual monitoring has to adapt according to the changes in the object of control and environment (signal R'''). Necessary models are formed in IDSS. $Y_{IM} = \{X, X', X''\}$, where X – results of information collecting in the system of monitoring, X', X'' – sets of results of the model assessment and the preliminary forecast of the state of HRP.

The structure of IDSS is defined by its functions (see Fig. 3). In Fig. 6 the IDSS model that includes the following main systems: *Knowledge Base*; *Modeling*; *Formation of Alternative Scenarios of Control; Regulation of the Structure of Monitoring System* is schematically presented. The Knowledge Base contains: information, collected and previously processed in the monitoring system, which is used inside IDSS for carrying out spatiotemporal analysis, modeling, imitating experiments in the form of elements of the set D; the models developed and used both inside IDSS and for formation of sets R, R', R'', R''' (elements of the set M); rules P necessary for formation of models.

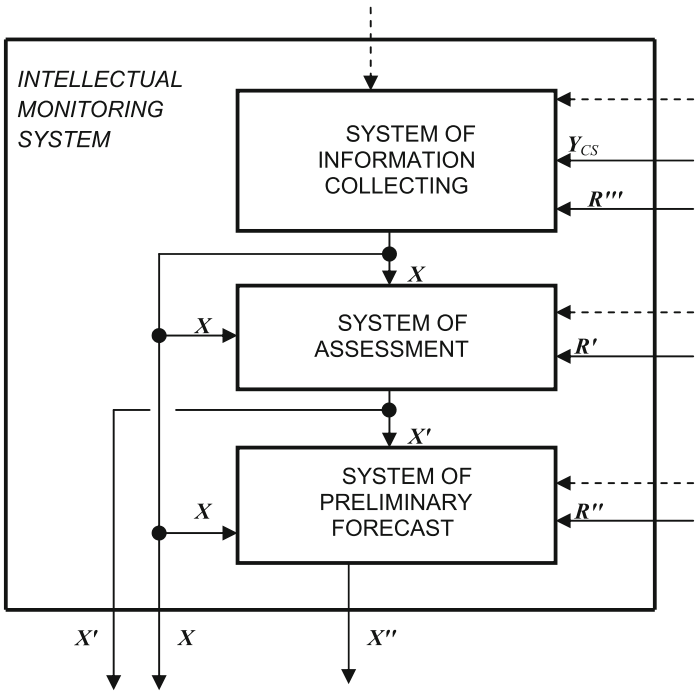

Fig. 5 Model of the intellectual monitoring system as a part of SCS

Modeling system using the information of the knowledge base forms the models necessary for the solution of a full range of problems of SCS of HRP. During identification of new cause-effect links in the course of modeling new rules are also formulated ($\boldsymbol{P}'$).

In the system of formation of alternative control scenarios on the basis of the carried out estimations and forecasts possible control influences are defined and alternative scenarios of control of the human resources potential of the region are formed; they are transferred to the control system of SCS of HRP (besides they are stored in the knowledge base).

In the figure there are $\boldsymbol{M_1}$, $\boldsymbol{M_2}$ – models constructed by the modeling system for formation of alternative scenarios of controls of HRP and regulation of the system of monitoring respectively.

6 Summary, Conclusions and Implications

Construction and organization of a Smart Control System with use of the presented models will enable to provide effective intellectual decision support and on this basis realization of productive managing decisions on the balanced formation and development of the human resources potential of the region.

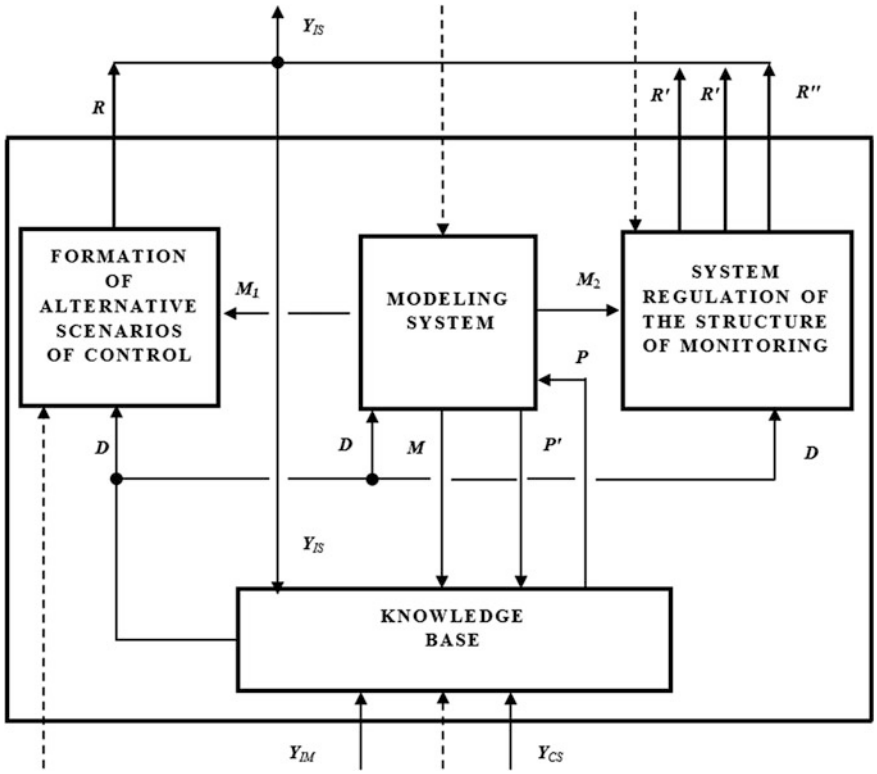

Fig. 6 Structural model of Intellectual decision support system

It should be particularly noted that such systems have to become an integral part of the general intellectual network of control of "Smart City". The ideology of "Smart City" was created and is developing actively for the purpose of providing real favorable conditions for sustainable social and economic development of the territories of modern states, self-sufficiency of their sociocultural space, attraction and preservation of human resources potential.

It is necessary to emphasize that for real implication of investments, innovations and talented people from various spheres of economy and science, it is essential that "Smart City" not simply meet the modern requirements on natural and energy resources use, environmental standards, improvements and safety of its territory. It has to provide the most favorable climate for a person's development (his intelligence, creativity, cultural level, etc.), possibility of comfortable effective work, minimum time and human expenditures on receiving services of any kind, which, in turn, will propel the economy of a city and a country as a whole to the totally new level of development. Thus, it is necessary not only to introduce innovations while constructing "Smart City", arranging its essential services, education and creation

of new workplaces, but also to ensure innovative approach while arranging how to apply intellectual resources of the city.

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