Model of a domain-specific profiling system based on Explainable AI technologies

V.V. Antonov¹, Z.I. Kharisova², L.E. Rodionova¹, G.G. Kulikov¹,³
¹Ufa State Aviation Technical University, Ufa, Karl Marx. str., 12, 450008, Russia
²Ufa Law Institute of the Ministry of Internal Affairs, Ufa, Muksinova str., 2, 450103, Russia
³CJSC «Ufa Scientific and Production Enterprise "Molniya", Ufa, Zentsova. str., 70, 450052, Russia
E-mail: antonov.v@bashkortostan.ru, zarinaid@mail.ru, lurik@mail.ru, grisha@molniya-ufa.ru

Abstract. The article offers a system model of intelligent profiling system that opens up opportunities for both staff selection and effective training and rotation of existing employees of the organization. To implement this paradigm, state registers of open information resources are defined and created. From the point of view of science, the system model corresponds to the structure of the expert system of explainable artificial intelligence (XAI), which has the task of forming many solutions. The task is set to provide validation and verification of the models taking into account the uncertainty. The tool to improve this approach is a software analytical complex, the development and implementation of which will allow to search and effective analysis of data, forming indicators for their subsequent use in decision-making in the management of organization processes. Presentation of knowledge about the subject area under study in the form of system model allows applying formal logical rules, graphoanalytic metalanguage and rules for development and design of program analytical complexes.

Keywords: artificial intelligence; explainable artificial intelligence; ontological model; neural network technologies, profiling; software analytical complex

1. Introduction
It should be noted that the problem of training and effective use of highly qualified specialists is a strategic state task regularly outlined in the decrees of the President of the Russian Federation. The requirements currently imposed on employees of most enterprises and organizations are based on the need to possess a complete system of knowledge, skills and competencies that are formed in the course of training and its practical activities, as well as the need for professionally significant psychological qualities of the individual, psychological stability and readiness to effectively perform production and service tasks.

Increased requirements for employees pose complex tasks for HR employees, who must not only find candidates who meet their professional qualities, but also predict their behavior for compliance with the law, moral, ethical and other necessary requirements.
The proposed concept of a system for profiling based on the structure of hybrid expert systems will effectively solve the problems of personnel selection of employees, the formation of a personnel reserve system, as well as high-quality training and retraining of employees.

Under profiling is commonly understood as the direction in psychological science to reveal the components of verbal and nonverbal behavior of the character used in interpersonal communication, including in the form of a be-contact detection of deception and psychological observations of subjects to identify non-standard reactions [1]. Profiling methods are based on the analysis of characteristic informative features of appearance, behavior, and the use of observation and survey technologies in order to identify individuals with tendencies to deviant behavior. Predictive identification of such individuals for proactive actions is a priority for most organizations according to Russian Federal Law of 30.11.2011 № 342 “On Service in the Internal Affairs Bodies of the Russian Federation and Amending Certain Legislative Acts of the Russian Federation”.

2. Profiling and personnel selection

In accordance with the existing requirements, candidates accepted for certain positions, specialties and a number of departments undergo special psychophysiological studies and testing, the results of which allow us to conclude that it is appropriate to accept the candidate in question. However, along with the possible error of the interpreter, there is a problem of well-known tests and research methods, which significantly reduces the effectiveness of personnel selection.

Currently, a number of commercial structures are widely implemented so-called Data Leak Prevention (DLP) systems as technologies to prevent leaks of confidential data from information systems [2]. The use of DLP systems is aimed at: identifying the destructive behavior of employees; minimizing the risks associated with the disclosure of official information; improving the efficiency of work related to the processing of information in automated systems; conducting data analysis and interpretation [3]. The presented technology is very effective in analyzing information about a potential candidate. This is about the candidate's behavior model. In this case, there is a restriction on the reliability of the result, since the model is an abstraction, where not all parameters-properties of the candidate are taken into account.

The concept of the proposed system lies in the availability of semi-structured data in open information sources hypertext digital environment (such as Internet, Intranet, etc.), synthesis technology profiling systems artificial intelligence (SAI) and presents a profile system based on technologies XAI, designed to detect destructive behavior, and the neural subsystem that is used to test the reliability of the received data. Currently used neural network technologies SAI [4-6] have proven themselves in classification problems when working with big data and for this reason are used in the system under consideration for data verification.

Using the data available in memory, SAI are able to learn and present a forecast based on the curves of probable solutions. Accordingly, it is not difficult to imagine a system that takes into account the characteristics of a potential candidate for the service, work experience and interview questions with candidates, as well as predicts how likely it is to match the position being filled [7].

When selecting candidates for positions, the number of positions and their requirements (full name, position, education, age, and work experience) are first determined. After that, an order is drawn up, which specifies the terms for providing a list of employees formed for a particular position. Then the employee's personal qualities and professional qualifications are evaluated using a personal card, autobiography, characteristics, and test results. Also, an interview is organized to identify the employee's motivation, aspirations, goals, and distinctive individual competencies. The employee's labor productivity over a certain period of time is considered. Then, applicants for certain positions of the personnel reserve are compared by evaluating professional knowledge, experience and skills in the form of testing (evaluation forms), the results obtained are processed, and the competition Commission forms a set of recommendations for each applicant. After the list of candidates for the position is formed, it is adjusted. Then the lists of applicants are approved by the heads of structural divisions and heads of enterprises. Next, an individual development plan of the employee, an individual internship plan is
drawn up. All data is stored in heterogeneous storage, ensuring integrity, order, and consistency. Analytical data processing will allow you to extract the necessary information for making a decision.

In addition to the exhaustive number of required skills for a specific position, it is necessary to take into account emotional and psychological characteristics, such as: ambition, learning ability, purposefulness, etc., determined by the profile subsystem, which is collected through testing. Through this SAI, the applied software and analytical complex (SAC) will be able to identify suitable candidates and highly effective employees, as well as provide a transcript of video recordings of interviews. In addition, the SAI is able to identify stress zones, possible violations of rules, norms and other forms of risk, and non-compliance with established requirements in the service. Separately, you can emphasize the possibility of analyzing the experience, skills and results of certification of each candidate, and then determine the skills that need to be improved in order to increase the degree of compliance with the position.

3. System models and profiling directions
The concept of the proposed system allows you to simultaneously view the results for various categories of employees and employees, and form expert opinions both individually and by Department. When creating a conclusion, the expert can use automatically generated data: estimates received by the employee, automatically created text interpretations of the results.

The intelligent system allows you to prepare a set of related data, based on which it is possible to analyze the communication characteristics of an employee and forecast the assessment of changes in working behavior (slow response to tasks, failure to meet deadlines, etc.), comparing this data with typical characteristics stored in the system memory.

We will conduct an ontological analysis of modern profiling trends. Criminalistic direction, in a broad sense, is defined as a set of psychological methods and methods that determine the character, temperament, intelligence of the person who committed an offense or crime [8-10]. Forensic profiling has several main levels: lie detection (for verbal and non-verbal communications); diagnostics of lies based on suspicious behavioral signs, such as physiological symptoms of lying (changes in the autonomic nervous system – sighs, redness of the skin, excessive sweating of the forehead and palms, apnea, obviously shaking hands, pulsation of the carotid artery, sitting on the edge of a chair, trembling in the knees, body turned away from the employee), facial expressions and gestures during deception (scratching different parts of the body), as well as speech structures that give out lies, and eye signals), identifying the congruence of linguistic information, non-verbal communications [11]. In his works, Paul Ekman points out the signals of emotions that need to be paid attention to when determining the truthfulness of testimony – facial expression, voice, gestures, manifestations of the autonomic nervous system, since there is a possibility of verifier errors [12].

Forensic profiling is mainly used in the detection and investigation of offenses and crimes. One of the directions of this profiling is the preparation of a psychological and forensic portrait [13]. Thus, the Russian scientist A. I. Anfinogenov States that "The psychological portrait of a criminal is a psychological and forensic method and the result of knowledge of a criminal event, focused on identifying a set of information about the individual characteristics and personality features of the subject of the crime, manifested in the totality of circumstances and traces of criminal activity." The main characteristics of profiling are: gestures, emotions, psychology, facial expressions. There are personnel, forensic and commercial profiling, the ontological structure is shown in the figure 1.

This ontological metadata structure is used in the PAK structure for staff selection and it takes the following form:

\[ M^{onto} = \{ C^M, P^M, K^M \}, \]

where \( M^{onto} \) – metadata ontology;
\( C^M = \{ C_1^M, \ldots, C_i^M \} \) – many metadata concepts;
\( P^M = \{ P_1^M, \ldots, P_j^M \} \) – multiple relationships between metadata concepts;
$K^M = \{ K^M_1, ..., K^M_h \} \quad \text{– many properties of metadata classes.}$

"Metadata Ontology is a top-level ontology that contains the basic concepts and relationships between them, which are then used to build spatial and attributive ontologies", as defined by the definition borrowed from the [14].

The Ontology of Profiling describes the main concepts and types of profiling (human resources, forensic, political, etc.) as well as the objects that serve as sources of knowledge for the organization (figure 2). The Ontology of Profiling Structure contains the concepts and relationships required to form a hierarchy of knowledge areas and then use this hierarchy of SAC. This hierarchy reflects the subject areas related to different activities of the organization, i.e. those areas of knowledge in which the company is interested.

With the help of the Protégé ontology engineering tool in the OWL language, a model system was created for ontology visualization. As a result, classes of diagrams of the developed ontologies have been obtained which can be used to demonstrate the results of the simulation.

Some authors highlight the research direction - this understanding corresponds to the method of systematic classification of facial expressions. Attention should also be paid to the medical and psychological area - in the scientific world this area is based on the work of Russian psychiatrist Peter Gannushkin and German clinician Karl Leongard. In addition, there is a special area related to the work of special services around the world and the existence of specific files of persons in databases. The psycho-technological direction is actively used - based on the use of neurolinguistic programming for the subsequent development of a program profile of a person, his or her system of values and beliefs [15]. The process of communication in research consists of such components as subjects, means, needs, motivations and goals, ways of interaction and mutual influences, results. In communication, a person acts as a "subject", using means of communication such as speech, mimicry, pantomime (posture, movement, gait, gestures) and manner of holding on. In order for professional communication, understanding and perception to take place, it is necessary that non-verbal and verbal factors have a complex effect.

A number of features of professional communication can be highlighted, such as:
- communication orientation (personal or social orientation);
- quantitative parameters of communication (degree of mediocrity) - direct face-to-face communication or indirect communication of documents;
- regulation of communication (legal deontology norms);
- dynamics of communication (change in psychological content from contact to contact).

Thus, it is possible to talk about relations between objects, where both the objects themselves and the rules of relations can be presented as a semantic model of interactions in the information environment.

The task of recognition through non-verbal channels arises, such as seeing that the person speaking is lying or telling the truth. Non-verbal signals from the object of analysis are an important source of data, for example when assessing the validity of the information provided to them. For example, in the case of conscious lies, certain stress markers appear, e.g. the voice sounds higher, pauses become more frequent in order to speak and invent at the same time. Using artistic techniques, you can demonstrate unnatural attacks of coughing, yawning, crying or laughing. The crossed arms, whose hands lie on the shoulder, speak for the nervousness of the person. Gestures such as "crossed arms" and "crossed legs" testify to the closedness of a citizen, which does not always have a positive effect on the outcome of an important conversation. A person has much less control over his or her gestures and postures than over his or her words. To form a primary opinion, it takes 2-4 minutes to evaluate not only what a person is wearing, but also their manner of holding on, their gaze, smile and facial expressions, which often reveal hidden intentions and thoughts [16]. In the profiling, elements of visual psychodiagnostics are used, which highlight the pattern of human perception.

In the profiling, elements of visual psychodiagnostics are used, which highlight the pattern of human perception. When a person meets, the first thing they consider instantly and unconsciously is gender, age and build. The human perception scheme is based on the principle of the general to the particular, evaluating external features, facial features (proportions, features, smile, look), gait, posture, gestures (features of hands, fingers), clothing (colour preference), makeup, etc. Visual psychodiagnostics uses various visual aids such as observation, video recording and document examination [17,18].

A result of SAC's work, it is possible to obtain an effective tool for selecting and analysing candidates for the service (work), presented in tabular or graphical form. This SAC primarily solves the problem of ensuring the storage and collection of data, processing and structuring of data clusters, integration into other systems. The main principles of subsystems implemented in the SAC are the principle of developing structure, adaptability and independence of the operated subsystems and databases.

SAC, according to ISO/IEC/IEEE 15288 [19] system engineering standard, includes the following stages:
- conception ($M_1$);
- developments ($M_2$);
- production ($M_3$);
- applications ($M_4$);
- application support ($M_5$);
- termination of application and write-off ($M_6$).

The application of virtual models and objects describing the possible behaviour of a person or his or her condition will make it possible to monitor and take preventive measures in real time and forecast possible negative actions and phenomena. Considering that the information system during the life cycle (LC) consistently passes through stages that are milestones that record more significant changes in the state of the system. The LC model can be represented as a sequence of stages [20], and the structure of the system within each stage remains constant.

The scheme of relationships between subprocesses in this case is fully consistent with the provisions of ISO/IEC/IEEE 15288 international standard for system engineering [21]. In other words, there is a category set mapping that preserves the structure of these category sets, and the SAC system model can also be fully formed according to the requirements of this system engineering standard.

ISO/IEC/IEEE 15288 system engineering standard is applied to describe the LC in a BPMN notation. According to the designations entered, which are presented in Figure 2.
Let us look at the application stage in more detail [20].

The application phase \( M_4 \) begins after the software system has been installed and handed over for use by the customer [20].

Planning begins at previous stages.

The purpose of this stage is to ensure that the system is functioning with guaranteed performance.

The parameters under study:

1. Production stage result \( M_3 \).
2. Performance monitoring, identification and classification indicators \( MM_2 = \{ mm_2^1, ..., mm_2^i \} \):
   
   3. Reports on deviations, disadvantages and failures \( MM_3 = \{ mm_3^1, ..., mm_3^i \} \).
   
   4. Information on necessary changes to the product configuration (version) \( MM_4 = \{ mm_4^1, ..., mm_4^i \} \).
   
   5. Stage results used for recursive analysis \( MM_5 = \{ mm_5^1, ..., mm_5^i \} \).

   – experienced personnel with the level of competence required to perform the functions of operators in the software system in question and to provide relevant services are identified;
   – an established software system capable of providing functional services is applied;
   – compliance with the system's objectives is monitored;
   – problems are identified, with users, developers and manufacturers getting to know each other and making adjustments;
   – plans are made and criteria for moving to the withdrawal and write-off phase are defined.

6. Stage results to be applied in subsequent stages (problems detected are resolved):
   – inactivity;
   – software system maintenance;
   – slight reengineering;
   – determining the transition to the next stage of withdrawal and write-offs.

7. Results applied by the development \( M_2 \) and \( M_3 \) production phases (actions taken when errors are detected) \( MX_6 = \{ mx_6^1, mx_6^2 \} \):
   – reconfiguration of the system in order to extend its LC;
   – Identification of new opportunities for upgrading the software system by applying feedback from the rights holder.

Considering this process of the application stage in Figure 3 as relations, we can show that relations and conclusions have an iterative component (recursion). When designing a software analytical complex, this process allows us to build an iterative model. At the same time, the time it takes to design and develop a SAC is reduced by introducing feedback. ISO/IEC/IEEE 15288 identifies iterative relationships as functions (i.e. how inputs/outputs are described), and input/output relationships are not formalized in this standard. The relationship can be considered as an analogue of the Zahman matrix, where columns are categories and rows are categories, when columns and rows are crossed the cells that form new categories. Each stage in ISO/IEC/IEEE 15288 is treated as a separate category. The methodology of this standard makes it possible to link each stage by introducing a recurrence relationship [24].
SAC modules are used as information objects, which allows for the construction of an adaptive system that is universal for changing external data. Such a mechanism helps to examine the subject area from different angles and develop a compact and universal software system, as the programme works according to a given algorithm and can be changed by adding only other parameters to the knowledge base (KB).

As a result, it is possible to create a virtual physical and digital environment in which people and information systems interact and evolve from isolated solutions to the formation of "smart information spaces".

Smart Information Space refers to a set of open Internet resources that use common languages and development methodologies for joint decision making.

To implement this model, we will define the following register of open information resources included in the SAC structure, including Google, Yandex search engines, personal Windows, Mac OS and Linux operating systems. Various cross-platform technologies that allow recruitment of Potok, Amazing Hiring, HireVue, Experium and others. Data from open Internet resources are included in the PAC system model, which corresponds to the structure of the expert system based on Explainable AI technologies.

4. Conclusion

The experience of foreign countries in introducing SAI in activities related to personnel management shows its effectiveness [23-27]. The use of SAI for various types of law enforcement activities, including forecasting, identification of potentially dangerous situations, etc., is promising [25-27]. Synthesis of such systems leads to the formation of "smart information spaces" that allow to solve a variety of tasks to achieve the goals of effective activity of organizations both in terms of formation of personnel policy and implementation of production activities. At the heart of such "smart information space" is a subsystem of profiling, which has the ability to predict the behavior of the evaluated individual, his potential, weaknesses and propensities based on private features such as appearance, verbal and non-verbal behavior, etc.

The question of rules for the use of such systems remains unresolved, even if a high degree of compliance of the forecast with the real consequences, a person's choice as an integral property of the personality should always be taken into account when making final decisions based on this forecast. Therefore, the use of XAI technologies to provide explanations in the form of "evidence or justification
for each result”, with the possibility of detailed explanation of how the PAK generated the final result significantly expands the scope of use.

The proposed systemic approach allows, among other things, taking into account and formalizing many behavioral and cognitive aspects of human activity models. Combining groups of objects (people and information systems) into separate new virtual objects - categories, description of their properties and relations through categorical relations taking into account ontological (causal - investigative) aspect [20, 21]. It makes it possible to form new synthetic models of so-called small groups - of production, service or scientific nature.

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