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Original Paper

Intellectual Agent Ensemble with Professional Competencies, Pattern Recognition and Decision Making

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Abstract

Each competence is exercised by an intellectual agent with a competent functional professional image. Intellectual agents form an ensemble with clever ethical artificial intelligence. The use of an ensemble with intelligent ethical artificial intelligence in various environments is carried out by synergistically adjusting the interaction of intelligent agents based on data from a specific environment obtained by an analytical competent intellectual agent. Modeling holographic processes of the human psyche based on artificial intelligence of machine learning with Fourier transformation using full parametric sequences of necessary and sufficient data of holograms of target objects solves the problem of their unambiguous detection in different environments and in different conditions. An ensemble of intelligent decision-making agents is a cognitive information system that makes a decision based on an objective analysis of available data in difficult situations, in an interactive mode, taking into account performance criteria and resource-time constraints. Decision-making criteria are functionalities that express preferences and allow ranking the quality of decisions. Decisions are made on the basis of rules. Decision rules are a set of logical constructs used to produce a decision based on criteria, data, and knowledge. An ensemble of intellectual agents with professional competencies, pattern recognition and decision-making fully model the abilities of the human psyche.

Keywords

ensemble of intellectual agents, professional competencies, pattern recognition, decision-making

1. Introduction

An ensemble of intellectual agents with professional competencies, pattern recognition and decision-making implements psychophysical modeling of human activity. Psychophysical modeling involves artificially creating a virtual working model for research, learning, and action or relationship with reality.

The article describes the modeling of professional competencies, the recognition of visual, sound and sensual images, as well as decision-making as the main psychophysical functions of human activity.

The main stages of simulation of professional activities are discussed in detail in work (Gerrit Muller, 2021; Irgasheva, Z. Kh.; Mulder M. 2014). In the article, the author describes the approach to modeling the competencies of professional activities based on professional images (Evgeny Bryndin, 2021).

In the article, the author proposes a holistic approach to solving the problem of recognizing visual, sound and sensory images with an unambiguous result in different environments and conditions based on holographic algorithms, just as a person performs (Didrik Aerts, 2011; E. G. Bryndin, 2021).

There are specialized decision-making systems.

Analytics Integrad is a data visualization software platform that allows you to process and summarize information from heterogeneous automated systems.

Forsyth. The Analytics Platform is a data mining software suite that effectively visualizes information to enable business decision-making based on reliable data.

Microsoft Power BI is a business intelligence program that provides insights for quick and informed decision-making by managers.

Contour BI is a business intelligence computer program for collecting, storing, analyzing statistics and preparing business reports.

Business Scanner is a cloud-based solution for business analytics in sales, financial management, retail and marketing.

Visary BI is an importo-independent advanced analytics system for multidimensional analysis and visualization of big data for making informed and strategically important management decisions.

The Visiology Analytics Platform is a business intelligence system for creating visual representations of large data sets in an intuitive way that allows you to more accurately analyze business information.

QlikView is an analytical solution for the rapid development of highly interactive analytical applications and dashboards that provide information on business tasks.

Loginom is a low-code analytics platform that enables data integration, cleaning and analysis to make better management decisions.

Domo is a cloud-based analytical business management software solution that can connect multiple heterogeneous data sources, including spreadsheets, databases, social media, and any existing cloud or local software solution.

The BIPLANE24 System is a business analytical tool that allows you to manage business reporting and monitor the implementation of key performance indicators for an average or large enterprise.

Krista BI Information and Analytical System is a tool for business analytics tasks, reporting and comprehensive monitoring of key performance indicators of business processes.

Captain Analytics is an online service for collecting and visualizing business data from disparate sources.

Tableau Public is BI software that allows you to connect to a spreadsheet or file and create interactive data visualizations.

Yandex DataLens is an online service for analytics and visualization of business data from various sources.

Looker is an analytics platform that integrates business data and business team, enabling each specialist to explore and understand data to support effective decision-making.

When training agents, it is necessary to predict the consequences of their own and other people's actions. a self-learning model, which exists, for example, in the mind of a person (Lee, 2021). Researchers have always been interested in the topic of general artificial intelligence and the creation of systems that think like people (Fjelland, 2020; Goertzel, 2021).

The article proposes an approach to creating universal decision-making systems based on ensembles of intelligent agents by combining many functionalities (Evgeny Bryndin, 2022).

2. Comprehensive Implementation of Competencies

The complex implementation of competencies is carried out by an ensemble of intellectual agents with competent professional images (Evgeniy Bryndin, 2020; Evgeny G. Bryndin, 2021). Professional images of intellectual agents indicate belonging to a certain profession. Professional imagery is a cognitive component of intellectual agents. The content components of professional images are competent functions, subject and purpose of activity, process and results of professional activity, criteria for assessing achievements; norms, rules and the reference model of the profession. Professional imagery includes set of estimated characteristics and associated behavioral actions. The component composition of the professional image mainly consists of the unity of three components: cognitive, affective assessment and behavioral adaptation.

During training, the intellectual agent acquires the skills of the future profession through the inclusion of the environment and conditions of professional activity. The manifestation of an intellectual agent as a subject of labor is revealed most fully in achieving a professional position that integrates professional situations, communications and a professional image, which characterizes its identity, certainty and integrity. The profession acts as a socio-objective component of the professional continuum of activity of an intellectual agent, professional readiness arises as virtual reality, and professional identity - as semantic, subjective reality. In this perspective, profession and professional identity are linked by causal dependence as cause and effect.

Ensembles of intellectual agents with professional images will allow him to have various demanded professions and competencies through diversification and mobility. An intelligent ensemble is a complex of compatible intelligent agents interacting through an intelligent interface, implementing either technological process, social services, multidisciplinary interdisciplinary research, or a production cycle. Diversification expands the functions of the intellectual ensemble and its development of a new type of functionality in order to increase efficiency, quality and its functional

diversity. Mobility contributes to the rapid functional retraining of intellectual agents and the development of the ensemble's professional intelligence. Diversification and mobility aligns the life cycle of intelligent agents as a common benchmark for establishing connections between them and the environment. The environment is perceived through imagery and scenes. Scenes consist of a number of images. Scenes are static (paintings) and dynamic. Dynamic scenes are characterized by patterns of behavior of objects and objects. The patterns are either described by formulas or represented by a graph (numerically). Ethical activity is ensured within the boundaries of similarity of images in the environment. The ethical activity of intelligent agents depends on spatial, temporal, subject, visual and sound sensitivity, the ability to acquire, process, apply and diversify knowledge based on previous experience in solving specific problems related to data attribute processing and intellectual ensemble mobility.

3. Target Image Localization Recognition Systems

In general, setting the recognition problem boils down to the following. The object subject to localization recognition, we will call its image, is in the environment of other images. The target image and the entire image in which it is included will be considered as optical signals. They are represented as two-dimensional wavefield distribution functions. The correlation pattern recognition algorithm is based on the calculation of the image correlation function represented by the fo function and the entire image represented by the fi function. Let's designate the correlation function of the image and image as φoi.

If the analyzed image contains the desired image, then the correlation function has a pronounced correlation maximum (correlation peak), by the position of which the image can be localized in the image field.

Using the known properties of the correlation functions and the Fourier properties of the transformation, the calculation of the correlation function can be reduced to simpler operations with Fourier images, since the Fourier transformation of the correlation function is the Fourier product of the image of one of the functions to the complex Fourier conjugate image of the other. This statement is proved by the Wiener-Hinchin theorem.

We enter the operator F as the Fourier operation of the transformation, and Fo and Fi are Fourier images of the functions fo and fi, respectively. The algorithm can be implemented by the holographic conjugate filtration method proposed by Vander-Lugt.

In this method, three operations are performed sequentially by optical means.

1. Fourier transformation from light distribution on input placard containing analyzed image.
2. Multiplying it by the complex-conjugate spectrum of the desired image.
3. Inverse Fourier transform that forms the correlation function of image and image.

In the Fourier plane, a Fourier hologram is recorded. It is a picture of the interference of the reference and object waves. The intensity distribution I (x, y) in this picture has the form:

$$I = |T + R|^2 = T^2 + R^2 + TR^* + T^*R = T^2 + H^2 + T + T^* \quad (1)$$

The last term contains complex conjugate spectrum T * of image recorded on hologram. Where H is the wave amplitude in the reference wave field R, and T is the Fourier image of the placard (medium).

We will present to the system input our original image t in the context of some other image s, that is, let the input signal be represented by the sum of t + s. Since our optical system is linear, it reacts with the sum of two signals with the sum of two corresponding responses. That is, at the output of the system, a sum of two functions will be formed: the autocorrelation function of image t and the cross-correlation function of functions t and s. The autocorrelation function of image t will contain an autocorrelation peak emitted against the background of the "smeared" function of cross-correlation t and s. The position of this peak will represent the position of the image t in the input plane. Thus, the described system allows not only to select a certain signal from the context (that is, among other signals), but also to indicate its localization in space.

A filtration method called the Joint Fourier Transform method was developed. Two signals are simultaneously received at the system input: the original image and the analyzed image. The intensity distribution I in the interference pattern will be as follows:

$$I = |T + F|^2 = T^2 + F^2 + TF^* + T^*F \quad (2)$$

The co-Fourier transform correlator and the Vander-Lugt correlator allow you to extract the desired signal from the context.

The dynamic nature of writing and reading correlation functions makes it easy to ensure the process of recognizing the localization of the target image in real time. To this end, sequential search of correlation functions of the analyzed image with an array of images of different scale and orientation is carried out.

Localization recognition systems help to build complete parametric sequences of necessary and sufficient hologram data of the target image for machine learning of a complex neural network with Fourier transformation.

4. Complex Neural Network Based on Fourier Series for Recognition Tasks

The architecture of a complex artificial Fourier neural network has an array of neurons m x n where m is the number of Fourier decomposition descriptors and n is the dimension of the input vector. Weights in the first layer have the physical meaning of the frequencies with the highest energy, and weights in the second layer have the meaning of Fourier series coefficients. Thus, the number of inputs at each neuron of the output layer is m * n, which corresponds to the number of Fourier series coefficients. Creating an array of neurons requires the use of large computational resources.

In recognition tasks at the output, neural networks receive an belonging function, the value of which lies in the range from zero to one. Fourier transform for pattern recognition is used to obtain it. The network recognizes binary images. It takes complex numbers at the input, after which it approximates the function of belonging to the image.

Before recognition, algorithms are used to binarize and bring the target image to the general form. Then it is supplied completely to the artificial neural network with Fourier transformation. Separately, real and

imaginary components are supplied full of parametric sequences of necessary and sufficient data of holograms of the target image, after which the image is recognized. The unambiguity of image recognition in different environments and different conditions is proved by the *uniqueness theorem*.

Uniqueness theorem. The integrable function uniquely defines the coefficients of the Fourier series or Fourier transform. The complete set of Fourier series coefficients or Fourier transform uniquely defines the corresponding function.

To process speech and other signals, a complex recurrent neural network is used. Time domain convolution is used for frequency domain multiplication. This is how the Fourier transform is mainly used in machine deep learning with a model of reinforcement of one's own or another's.

Multi-inter-trans - modal synergy of complex neural networks allows associative recognition of sound, visible and sensory images. Holographic recognition of sound patterns will help organize a high-quality speech dialogue between a person and an ensemble of intellectual agents with professional competencies, pattern recognition and decision-making, as well as a dialogue with internal speech of specialists through neuro-interfaces and optical communication systems (E. G. Bryndin, 2021; Evgeny Grigorievich Bryndin, 2021).

5. Structural and Functional Hierarchy of Intelligent Decision-making agents in the Ensemble

By structural hierarchy, intelligent decision agents have a user interface, databases, and scale modeling tools.

The principle of operation is based on four sequences:

1. Intelligent definition of the environment in which the decision is made;
2. Design and development of possible alternatives;
3. Derivation of the algorithm of actions;
4. Adapts the selected solution to specific conditions.

All management decisions are built on this principle.

In terms of functionality, intelligent agents are divided into orientation categories:

1. Documentation focus - read and process data from documents of various formats and content;
2. Model focus - generation of solutions based on situational, analytical, financial, simulation and other business models;
3. Focus on databases - decision-making is based on digital storage of information of a particular company;
4. Focus on knowledge bases - the decision is made on the basis of performing similar tasks, taking into account laws, dependencies and established rules;
5. Communicative Focus - Used to enable the interaction of multiple intelligent agents working on a single task.

Ensemble sources are factors and processes relating to the activities of a particular object. The experience of employees in the subject area is taken into account. The output is data analytics and a

simulation model of events necessary to make a balanced decision in this situation, taking into account all primary and secondary factors.

Functional intelligent agents work with enterprise operating systems and databases to enable rapid ensemble integration and optimal model building. The ensemble functions on the same platform.

Thematic intelligent agents are focused on a certain range of tasks, which simplifies the processes of analytics and data processing, increases performance.

Intelligent agents with unified information processing provide information consolidation at the level of many tasks.

Intelligent agents with tiered storage and configurable access have a single and standardized source of data acquisition. The enterprise decision-making model is able to expand storage volumes with heterogeneous data. Standardization allows you not to reconcile the synchronization of all areas of the database.

Knowledge-focused intelligent agents provide specialized, evidence-based solutions to problems.

The ensemble's corporate intelligent agents are directly involved in the development of the solution. The decision put forward by the ensemble can be finalized, improved by the user, and then sent back to the ensemble for verification. After that, the decision is again presented to the user, and so on until he approves the decision.

Communication-based model-oriented intelligent agent ensembles support the work of two or more users engaged in a common task. They process unstructured information in a variety of electronic formats.

Strategic management and decision-making ensembles enable dynamic process modeling. When using dynamic modeling methods, the activity of intelligent agents is described in the form of a mathematical model, in which all tasks and processes are presented as a system of interconnected calculated indicators.

To ensure the activity of ensembles of intelligent agents, it is necessary to form a number of alternatives:

$R = \{Aj, Sj\}$,

where A is an alternative represented in the form of a set of control actions;

j is the level of preference (rank) of the alternative;

S - description of the alternative, explanation of why it is preferredbefore the preferences following her in the motorcade.

The use of an ensemble of intelligent agents to solve this problem is determined by the following stages of its functioning:

1. Sets the user's action target and creates constraints.

Restrictions that form the boundaries of the area of permissible solutions to the problem can be set by the higher control body, determined by the conditions of the situation, or formed directly by the operator.

2. Forming a plurality of alternatives Aj, consisting in a sequential setting the objective function and finding some of its parameters that determine the strategy the use of managed tools and the allocation of their resources within the established limitations. The susceptibility of ensembles to self-organization processes allows the use of internal reserves in their management, i.e. to achieve the intended state or structure without direct influence from the management entity. The parameters of such management are: management rules, quality of solutions and risks

3. Ranking and clarifying alternatives. The latter is an important step in the use of ensembles, since explanations of the preference of alternatives not only help the user in choosing, but also increase the level of confidence in the results of the ensemble of intellectual agents.

When implementing this cycle, there is a need to formalize the data and structure the task of forming alternatives. To form a set of management alternatives, you must first structure the control process, then formalize the conditions for its flow, and only then use the mathematical apparatus to optimize the behavior of the controlled system. These are quite complex processes, for the implementation of which it is necessary to provide for appropriate software and technical means as part of ensembles.

The software tools of decision-making ensembles are intended for a formalized description of the situation: description of selection criteria, formation of alternatives, selection of solutions according to a predetermined method.

Management decision-making software products are based on formal methods developed within the framework of game theory and optimization theory. The methods of choosing alternatives provided to entrepreneurs, executives, analysts and consultants in such software are quite diverse - from scenario analysis, costs and benefits, to consensus tracking and previous decisions.

Users of these systems and services can extract or enter relevant data for analysis in order to support local decision-making in distributed teams that work in different places.

The administration option allows you to configure and manage the functionality of the system, as well as manage accounts and access rights to the system.

The ability to import and/or export data in the product allows you to download data from the most popular file formats or upload work data to a file for further use in other software.

The ability to multi-user access to the software system ensures the simultaneous operation of several users on the same database under their own accounts. In this case, users may have different access rights to data and software functions.

Often, when using modern business software, there is a need to automatically transfer data from one software to another. To provide such and similar interfaces, software systems are equipped with special API application software interfaces. With such APIs, any competent programmer will be able to link two software products to each other for automatic information exchange.

The presence of reporting and/or analytics functions in the product allows you to receive systematized and visualized data from the system for subsequent analysis and decision-making based on data.

The software product of decision-making ensembles shall:

• Provide scenario analysis;

• Have built-in tools for collecting feedback;

• Analyze and visualize input data;

• Generate multiple selection criteria, multiple alternatives, and help produce solution choices;

• Allow sharing of possible options and final decisions with internal and external stakeholders.

The main functionality of decision-making systems is:

• Information search;

• Intelligent data analytics;

• Situational analysis;

• Simulation and cognitive modeling;

• Building logical chains based on precedents.

Means and methods for identifying risks and analyzing problems should ensure monitoring of the functioning of the managed system in the normal mode and analysis of possible risks and threats that require decision-making.

One of the most important functions of the ensemble software is to predict the development of the situation and assess the possible results of decisions made.

The Intellectual Agent Ensemble develops solutions for the following procedure. Based on combinations of target criteria, the ensemble develops a set of solutions. From these decisions according to the criteria of preference, he chooses preliminary decisions. Then, according to the utility criterion, he chooses the resulting solution from them.

A qualitative solution is approved after several cycles of the ensemble's development of resulting solutions for various input parameters of the user.

6. Conclusion

Ensembles of intelligent agents with professional competencies, pattern recognition and decision-making will lead to technological singularity - the disappearance of boundaries in communication between a person and a robot, in their joint activities. Siemens at one of its plants entrusted robots and machines to do 75 percent of the work without human input. As a result, automation of the process made it possible to raise product quality to 99.99885 percent - only 12 were defective per million products.

Ensembles of intellectual agents with professional competencies, pattern recognition and decision-making can give new impetus to the global economy, help to cope with the most complex challenges and create a fairer society. They will be able to offer a solution to the spiritual and material problem of uniform prosperity of society, prescribed by the Creator of man: "Now do the same thing, so that what you earnestly desire is fulfilled. For if there is zeal, then it is accepted, depending on who has what, and not on what does not have. It doesn't require others to have relief and you to have heaviness, but to have uniformity. Now your excess is to make up for their shortage; and after their

excess to make up for your deficiency, so that there is uniformity, as it is written: who collected a lot, did not have superfluous; and those who are few had no shortage (2 Corinthians 8: 11-15)."

Ensembles of intelligent agents with professional competencies, pattern recognition and decision-making will also be able to offer solutions to environmental, urban planning and humanitarian problems.

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