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MANSHIN Nikita

Master thesis

«Framework Design for Knowledge Management System with Components of Artificial Intelligence»

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Academic advisor:
Head of the Dept. of ITM,
Candidate of Technical Sciences,
Gavrilova Tatiana

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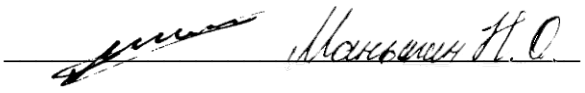 (Signed and transcribed by the student).

19.05.2022 (Date)

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Abstract

ABSTRACT

Master Student's Name	Nikita Manshin
Academic Advisor's Name	Tatiana Gavrilova
Master Thesis Title	Framework design for knowledge management system with components of artificial intelligence.
Description of the goal, tasks and main results the research	The *goal* of the master thesis is to explore the company's needs in order to design a framework for the knowledge management system with the elements of AI based on the investigated internal business processes and reviewed trends and key concepts in IT, KM and AI. To achieve the stated goal, the following *tasks* should be completed: • Explore the existing concepts, models and frameworks in the knowledge areas of KM and AI • Identify key outcomes to use in the foregoing analysis • Analyze the target company in terms of business processes and structure • Create a questionnaire and conduct a survey of employees • Gather necessary information about its knowledge sources and types and classify it • Develop a framework for knowledge management system with the elements of AI • Outline key possibilities and critical success factors of its implementation The *result* of the thesis will be the development of a framework for knowledge management system with the elements of AI.
Keywords	Knowledge management, artificial intelligence, knowledge graph, ontology, framework, business process, system, KM, AI, KG, KMS, BPR, IT.

АННОТАЦИЯ

Автор	Маньшин Никита Олегович
Научный руководитель	Гаврилова Татьяна Альбертовна
Название ВКР	Проектирование структуры системы управления знаниями с элементами искусственного интеллекта.
Описание цели, задач и основных результатов исследования	*Целью* магистерской диссертации является изучение потребностей компании для разработки каркаса системы управления знаниями с элементами ИИ на основе исследованных внутренних бизнес-процессов и рассмотренных тенденций и ключевых концепций в области ИТ, КМ и ИИ. Для достижения поставленной цели необходимо решить следующие *задачи*: • Изучить существующие концепции, модели и рамки в областях знаний УЗ и ИИ. • Определить ключевые результаты для использования в вышеуказанном анализе • Проанализировать целевую компанию с точки зрения бизнес-процессов и структуры • Составить анкету и провести опрос сотрудников • Собрать необходимую информацию об источниках и типах знаний и классифицировать их • Разработать структуру системы управления знаниями с элементами ИИ • Описать ключевые возможности и критические факторы успеха ее внедрения. *Результатом* дипломной работы будет разработка структуры системы управления знаниями с элементами ИИ.
Ключевые слова	Управление знаниями, искусственный интеллект, граф знаний, онтология, структура, бизнес процесс, система, СУЗ, ИИ, ИТ.

Introduction

Business has always been inextricable from competition. Companies are constantly competing with each other for a larger share of the market. Any discovery, expansion, even into new and unexplored markets (the Blue Ocean strategy) either immediately or over time, will lead to competition. The more developed a certain market or environment is, the harder it is to stay afloat in it. Moreover, as the economy develops more rapidly over time, there are many factors that determine the long-term success of an organization. For example, globalization and economic dynamism bring uncertainty in economic forecasts, turbulence, and increase the risk that traditional forecasts will lose their relevance and relevance in a matter of weeks. In addition, it is worth noting that globalization and internationalization of business have established robust knowledge-sharing channels that enable the sharing of best practices, frameworks and models. Only those who can remain flexible and responsive to market signals will reap the benefits. Finally, the accelerating development of new technologies not only presents new opportunities for businesses, but also new challenges. Those pioneering companies that get ahead of their competitors and adopt new technologies first will have a chance to gain sustainable strategic advantages that will set them apart.

Within the management consulting community, the concept and vocabulary of Knowledge Management (KM) arose. When the Internet became available, those firms rapidly discovered that an intranet, or an internal subset of the Internet, was a fantastic tool for making information accessible and sharing it among their geographically scattered units [2-3]. Not unexpectedly, they immediately realized that by developing tools and approaches like dashboards, expertise locators, and best practice (lessons learned) databases, they had developed experience that could be marketed to other organizations, particularly large, complicated, and scattered enterprises. However, a new product requires a name, and Knowledge Management was chosen. The word was reportedly first used in its current context in 1987 at McKinsey for an internal research on information handling and utilization (McInerney and Koenig, 2011) [25]. In 1993, during a symposium arranged by Ernst and Young in Boston, KM had its public debut (Prusak 1999). Davenport (1994) was working at E&Y at the time he authored the definition below: “Knowledge Management is the process of capturing, distributing, and effectively using knowledge.” Probably no better or more succinct single-line definition has appeared since.

One such new technological solution is **Artificial Intelligence**. As defined by Demlehner, Q. (2020) Artificial Intelligence (**AI**) is a collective term for computer systems having the ability to percept, learn, judge or plan without being explicitly programmed to follow predetermined rules or action sequences throughout the whole process [15]. Over the past decades, the field of knowledge about artificial intelligence has grown and evolved in various directions. The possibilities of using AI as an assistant in an organization are truly astounding. Research on the applicability of AI has been conducted in industries such as Omni channel retailing [11], car manufacturing, manufacturing, finance, consulting, agriculture, and others. Moreover, Petrin, M. (2019) performed a thorough study on consequences and requirements for possible implications of AI in various business processes through a prism of law. Among those, there were such jobs as visual quality control, production forecasting/planning, energy management, staff assignment, financial market forecasting based on news and reports. In addition, Chatterjee, S. (2020) proceeded with the study of implication of artificial intelligence to support CRM-KM symbiosis [13]. This opens a wide variety of possible usage of AI in business. In terms of corporate governance, Libert (2017) studied effects of AI from the side of law and came up with the following statements [23]. Due to AI's ability to efficiently handle high degrees of complexity, AI-managed businesses will be in a better position to pursue multiple objectives **simultaneously** – specifically the interests of multiple stakeholders – and optimize the outcomes of several objectives at once within given constraints. Secondly, the board's traditional structure will likely become **superfluous** in an age of AI dominated boards. Nevertheless, many researchers agree that AI in the boardroom "is not about automating leadership and governance, but rather **augmenting** board intelligence." This leads to the fact that delegation of important tasks requires for **major adjustments** in current framework.

Nevertheless, now the vast majority of research papers and studies are descriptive rather than experimental. This makes it difficult to analyze the applicability of specific frameworks in specific companies. Moreover, some academic papers that develop their own models and propose new concepts do not always provide the results of their validation. In addition, from the perspective of the Russian market, there is a noticeable lag in the degree of research and coverage of this topic for both the scientific and business worlds. The lack of articles and scientific papers on the topic of artificial intelligence in business entails a corresponding lag of Russian companies from their foreign competitors.

The topic of this paper is relevant because businesses have always faced the question of maximizing profits and sustainability of their business, which can be achieved by increasing the price of goods or services, obtaining external assistance or reducing all kinds of costs associated

with business processes. In case it is impossible to implement all of the above actions due to great competition, an excellent solution is to optimize internal processes, including the optimization of management of all kinds of sources and carriers of knowledge. SaaS companies, which, due to their focus on digital products and great competition, should be able to manage the knowledge associated with each accepted project or new client faster and more cleverly, are the best examples for this situation. Moreover, the new environment of the data overload and developing era of knowledge now affects companies' activities.

Thus, I believe that among the main objectives for this master's thesis, there would be the following: Review of trends in information technology development, review of the main methods of knowledge management, review of trends in the development and application of artificial intelligence in business, company overview and analysis of the current situation, description of the concept of the knowledge management system with the elements of AI, the development of such a system's framework and, finally, interpretation of research results and main conclusions.

Among the research questions, there would be the following: what are the key knowledge management and artificial intelligence concepts and frameworks? How artificial intelligence can be implemented in knowledge management system? What are recommendations for its application? In addition, it is worth determining in which industries this innovation is applicable as well.

The results will include a detailed description of existing concepts, a list of Key Success Factors, an evaluation of the selected framework by example of a company, and recommendations for the implementation of AI in the proposed framework of the knowledge management system, which would help Russian companies in the future to apply this technology to achieve sustainable benefits.

Chapter 1. LITERATURE REVIEW

1.1 Review of the literature on the topic of IT and business process re-engineering

Today, information technologies play a crucial role, having a significant impact on both the economic and social aspects of society. Penetrating into all spheres of production activities, they make it possible to build efficient management systems, thereby reducing the time and cost of tasks for the performer. The dynamics of information technology development and its involvement in everyday life are directly related to global economic growth. Thus, according to one American expert in the field of management G. Poppel, **information technologies (IT)** mean the use of computers and communication systems for creating, collecting, transmitting, storing, processing information for all spheres of social life. He sees them as part of the information business - some technological basis - and as a separate infrastructure sector, often developing autonomously. Five main trends in the development of information technology are distinguished:

1) **The increasing complexity of information products and services**. Software products, databases and data storages are constantly improving and becoming more complex, and the interfaces of human interaction and information technology are simplifying, creating a user-friendly environment [4].
2) **Interoperability**. With the development of information products, the ability to exchange this product between the user and the computer or between information systems becomes an important technological challenge, which concerns the compatibility of technical and software tools for processing and transferring the necessary information. Modern data exchange protocols make it possible to unify methods for solving such problems.
3) **Elimination of intermediate links.** The development of the ability to interact entails simplifying the delivery of information to its consumer. The need for intermediaries is eliminated, and the value chain is simplified.
4) **Globalization**. There is a process of internationalization of the software and product market, and through unified information technology companies can operate more profitably in the global market, immediately receiving comprehensive information.
5) **Convergence**. Convergence is the process of convergence and integration of heterogeneous electronic technologies as a result of their rapid development and interaction. The reception and transmission of audio, digital and video signals are combined in the same devices and systems, resulting in more useful products for the consumer [8].

If we consider the topic of transformation of the company and its processes from another point of view, one of the most effective methodologies of company development is reengineering. According to the definition from the book by M. Hammer and J. Champy "Reengineering the Corporation: A Manifesto for Business Revolution", reengineering is a fundamental rethinking and radical reorientation of business processes to achieve significant improvements in the crucial indicators of the organization, such as cost, quality and time [19]. Hammer suggested seven principles in his work:

1) Work should be designed to be results-driven rather than process-driven. The first principle states that tasks performed by different people can be combined into one specialized task. Take, for example, the redesign of a manufacturing company with separate divisions performing different functions in sequence. One defines customer requirements, another transmits information, and a third transmits it to various plants and warehouses. These sequential activities lead to errors, rework, and delays. Reengineering the company eliminates this "conveyor line" approach.
2) Involve the people who face the result of the process. This principle states that the work should be done by the person receiving the product, i.e. the consumer. This can be observed today as "self-service". For example, if the consumer encounters a problem, he must fill out the data himself, not some office doing it for him. This shifts the focus of the work to the consumer.
3) Combining data collection and processing units. This principle has matured and manifests itself in the concept of the division of labor. It means that data processing should be done by the same person who collects the data, because it reduces errors by eliminating external contact with the process. For example, a company has a structure in which one department collects information and another records it. With this approach, there will be a lot of errors in a shared database when transferring information from one department to another.
4) Shared databases to consolidate disparate departments. Advances in information technology allow a company to consolidate separate geographically dispersed departments using a common database. Centralized databases provide economies of scale, as well as flexibility and rapid response to customer requests as more favorable agreements are negotiated among vendors.
5) Building bridges between processes along similar lines. According to Hammer, business processes should be integrated rather than end results. Parallel functions should be coordinated using communication networks and common databases. These parallel

activities should be connected continuously and coordinated in the execution of the process. This will eliminate high costs and delays in obtaining process results.

6) Decision making should also be part of the work being done. There should be technology that facilitates decision making to reduce unnecessary controls and maintain control in the process itself. Hammer states that the decision must be made by the person doing the work. Processes can be improved by giving the doer authority and responsibility for decision making and workflow improvement. This is possible with an educated and knowledgeable workforce.
7) Data collection at the point of origin. This approach saves money by avoiding costly re-entries and invalid data records. It is about the principle of collecting information only once at the place where it was created. This eliminates the difficulties associated with transferring information, and it does not need to be recorded at different locations at different times [9].

To implement business process re-engineering (**BPR**), it is necessary to define the vision and goals of the business, define the process itself and methods of improvement, understand and measure the feasibility of the process, design the information system and determine the technological capabilities and, finally, test the prototype [9].

The transformed business processes will achieve benefits such as:

- **Complete customer satisfaction**. Customer needs are the priority that gives a clear vision to the organization. Customers, when they are given the best service that meets their expectations, it builds loyalty in them. Business process design and implementation is redesigned so that performance meets customer expectations.
- **Cost advantage**. As the entire process is redesigned, unnecessary costs are eliminated throughout the value chain. This reduces costs and cycle time by eliminating unproductive activities and organizing teams and radically improves the efficiency and effectiveness of operations.
- **Competitive advantage**. Business process re-engineering helps an organization focus on its core competencies, which gives it a competitive advantage. These core values are difficult for competitors to replicate because they become a signature feature of the firm. Gaining a competitive advantage gives the firm superiority in the broader business process.
- **Creating value for customers**. In re-engineering, the firm strategically places appropriate activities in the design, production, marketing, and support of its products and services to

provide customer value. The firm analyzes its value creation activities and compares them to those of its competitors to find ways to improve them.

- **A clear business vision**. Business process re-engineering gives the firm a clear vision that aligns its goals and objectives with the needs, desires and interests of the customer. Thus, the organization acquires a certain brand identity and an ideal structure aimed at the customer [9].

Based on all of the above, business reengineering can manifest itself in quite different ways, affecting both organizational and technological aspects:

1) Business processes are simplified;
2) The range of workers' tasks is expanded to improve overall productivity;
3) People within the organization become autonomous rather than controlled;
4) Emphasis shifts from the individual to the achievements of the team;
5) The organizational structure transforms from hierarchical to flatter;
6) Professionals become key focus points for the organization, not managers;
7) The organization becomes aligned with the end-to-end process rather than departments;
8) The basis for measuring performance shifts from activities to results;
9) The role and purpose of the manager changes from supervisor to coach;
10) People no longer care about pleasing the boss-they focus on pleasing the customer;
11) The organization's value system changes from defensive to productive [9].

It can be said that a company needs to go through a digitalization process to achieve its goals. Bart Benke, in his article “The Digital Race” [6] defined digitalization as maximizing the potential of digital technology through its use in all aspects of business - processes, products and services, knowledge, and decision-making approaches. It is important to emphasize that it will never be enough for digitalization to just to have technology as it is. For digitalization to be meaningful, there must be clear business objectives and data.

1.2 Review of the literature on the topic of Knowledge Management

According to J. Firestone (2000), **Knowledge Management** (**KM**) is a field in ferment and disorder. In any such field a first order of business is developing a conceptual framework to serve as a map for problem definition, analysis, measurement, impact analysis, software applications development and research of various kinds. And KM is not an exception [16].

Starting with the basic concepts, a **Complex Adaptive System** (CAS) is a goal-directed open system attempting to fit itself to its environment. It is "...composed of interacting..." adaptive "agents described in terms of rules" [30] applicable with respect to some specified class of environmental inputs. "These agents adapt by changing their rules as experience accumulates". The interaction of these purposive agents, though directed toward their own goals and purposes, results in emergent, self-organizing behavior at the global system level. This emergent behavior, in a sustainable CAS is itself adaptive. Emergent behavior is behavior that cannot be modeled based on knowledge of the system's components. It is the ability of CASes to adapt, along with their emergent behavior that distinguishes them from simple adaptive systems and from Newtonian systems that lack adaptive capacity.

The **Natural Knowledge Management System** (NKMS) is a CAS. It is the on-going, conceptually distinct, persistent, adaptive interaction among intelligent agents:

- whose interaction properties are not determined by design, but instead emerge from the dynamics of the enterprise interaction process itself;
- and that produces, maintains, and enhances the knowledge base produced by the interaction.

An Enterprise NKMS includes mechanical and electrical organizational components produced by it, such as computers and computer networks, as well as human and organizational agents. An intelligent agent is a purposive, adaptive, self-directed object.

In brief, the nature of knowledge management is that it is a complex process composed of the above task clusters broken down into task patterns, executed by agents through decision cycles composed of planning, acting, monitoring, and evaluating activities. Further specification of KM, therefore, involves breaking down these task clusters [9].

Knowledge Base of a System and Knowledge. A system's **knowledge base** is the set of remembered data, validated propositions and models (along with metadata related to their testing), refuted propositions and models (along with metadata related to their refutation), metamodels, and (if the system produces such an artifact) software used for manipulating these, pertaining to the system and produced by it. A knowledge management system requires a knowledge base to begin operation. And it enhances its own knowledge base with the passage of time because it is a self-correcting system, subject to testing against experience.

Then, Firestone proceeds with the concept of Business Process Hierarchies and decision cycles. Such business processes in the company are performed by individuals, teams and groups

[7]. Figure 1 presents the idea that any business process (including knowledge and knowledge management processes) may be viewed as a network of linked activities governed by rules or knowledge, aimed at producing outcomes of value to those performing the activities. A linked sequence of activities performed by one or more agents sharing at least one objective is a **task**. A linked, but not necessarily sequential set of tasks governed by rule sets, producing results of measurable value to the agent or agents performing the tasks, is a **task pattern**. A cluster of task patterns, not necessarily performed sequentially, often performed iteratively, incrementally, and adaptively, is a **task cluster**. Finally, a hierarchical network of interrelated, purposive, activities of intelligent agents that transforms inputs into valued outcomes, a cluster of task clusters, is a **business process**.

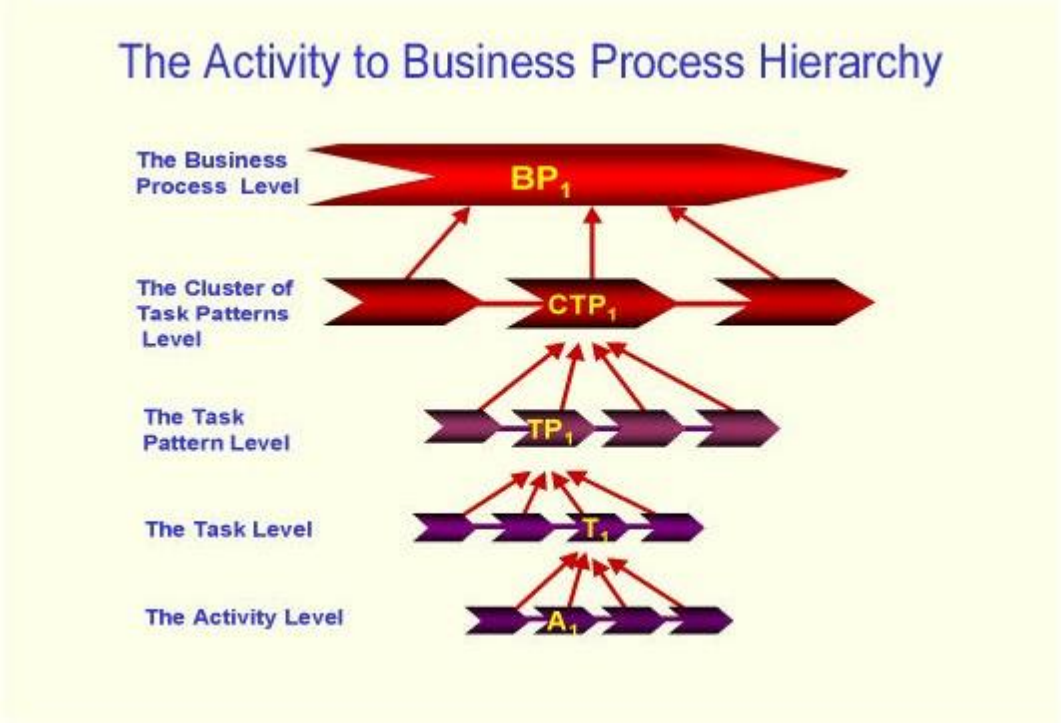

Fig. 1. The activity to Business Process Hierarchy

The generic task patterns or phases of any decision/execution cycle are: Planning, Acting (including deciding), Monitoring, and Evaluating.

- **Planning** is a knowledge production and knowledge integration task pattern. It means setting goals, objectives, and priorities, making forecasts as part of prospective analysis, performing cost/benefit assessments as part of prospective analysis, and revising or reengineering a business process. It involves capturing and using data, information, and knowledge to produce a plan, an instance of world 3 planning knowledge.

- **Acting** means performing the specific domain business process (cluster, pattern, or task) or any of its components. Acting involves using the planning knowledge, along with other world 3 and world 2 knowledge to make and implement decisions.
- **Monitoring** means retrospectively tracking and describing the business process (cluster, pattern, or task) and its outcome. Monitoring involves gathering data and information, modeling processes, and using previous knowledge to produce new descriptive, impact-related, and predictive knowledge about the results of acting. Monitoring is another (world 3) knowledge production and knowledge integration task pattern.
- **Evaluating** means retrospectively assessing the performance of the business process as a value network [21]. Evaluating means using the results of monitoring, along with previous knowledge to assess the results of acting and to produce knowledge about the descriptive gaps between business outcomes and tactical objectives and about the normative (benefits and costs) impact of business outcomes. Evaluating is yet another decision cycle task pattern that produces and integrates world 3 knowledge in the business process.

Three of these four phases require knowledge production and integration to solve problems that occur in each phase, and the fourth, the **acting** phase, uses the knowledge produced in the others [5]. Thus, every **decision cycle** in every business process requires both knowledge processing (production and integration) and knowledge use. Knowledge use is not a separate task but rather is part of deciding and acting. Nevertheless, planning, monitoring, and evaluating are knowledge production task patterns of different types, each involving sequential patterns of knowledge production and knowledge integration.

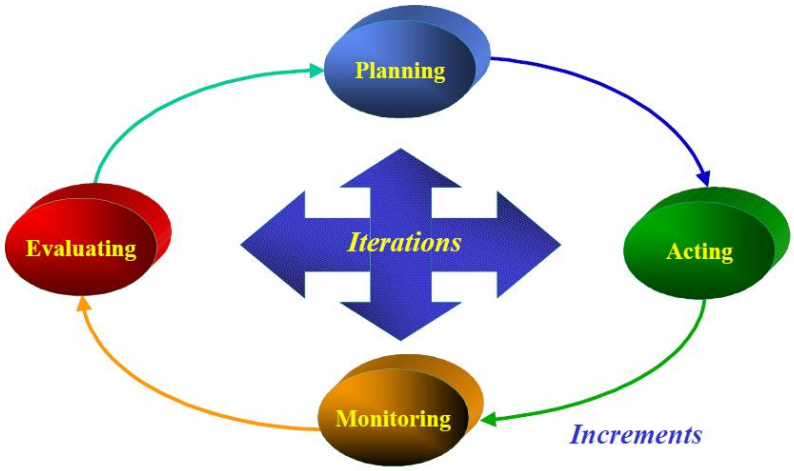

Fig. 2. Decision Cycle Phases and Their Interactions.

A widely recognized distinction in knowledge management circles is Polanyi's distinction [28, 37] between **tacit**, **personal** knowledge and **explicit**, codified knowledge. The distinction's

importance is emphasized in Nonaka and Takeuchi's [26] account of the “Knowledge Creating Company”. They assume that knowledge is created through the interaction between tacit and explicit knowledge, and they postulate four different modes of knowledge conversion:

- **Socialization**: Tacit to tacit knowledge, in which the knowledge of an individual or group is shared with the others;
- **Externalization**: Tacit to explicit knowledge, through which the knowledge is made explicit and codified in some persistent form;
- **Combination**: Explicit to explicit knowledge, where different sources of explicit knowledge are pooled and exchanged;
- **Internalization**: Explicit to tacit knowledge, whereby other individuals or groups learn through practice.

These modes are interchanging with the development of the knowledge through time, which is illustrated in SECI model presented in Figure 3.

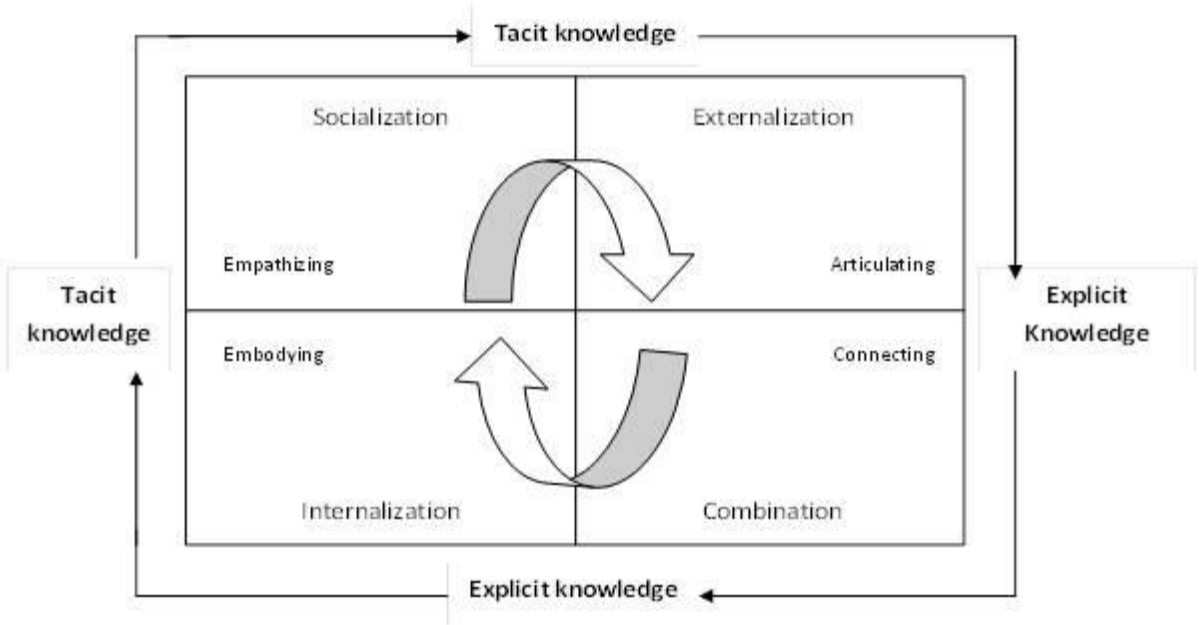

Fig. 3. SECI model

Explicit (codified) knowledge consists of data [14], information, documents and records while **tacit** is more comprehensive one, involving experience, thinking, competences, commitments and deeds.

Another model discussing the relationship between tacit and explicit knowledge is suggested by Boisot M. (1987) – Figure 4.

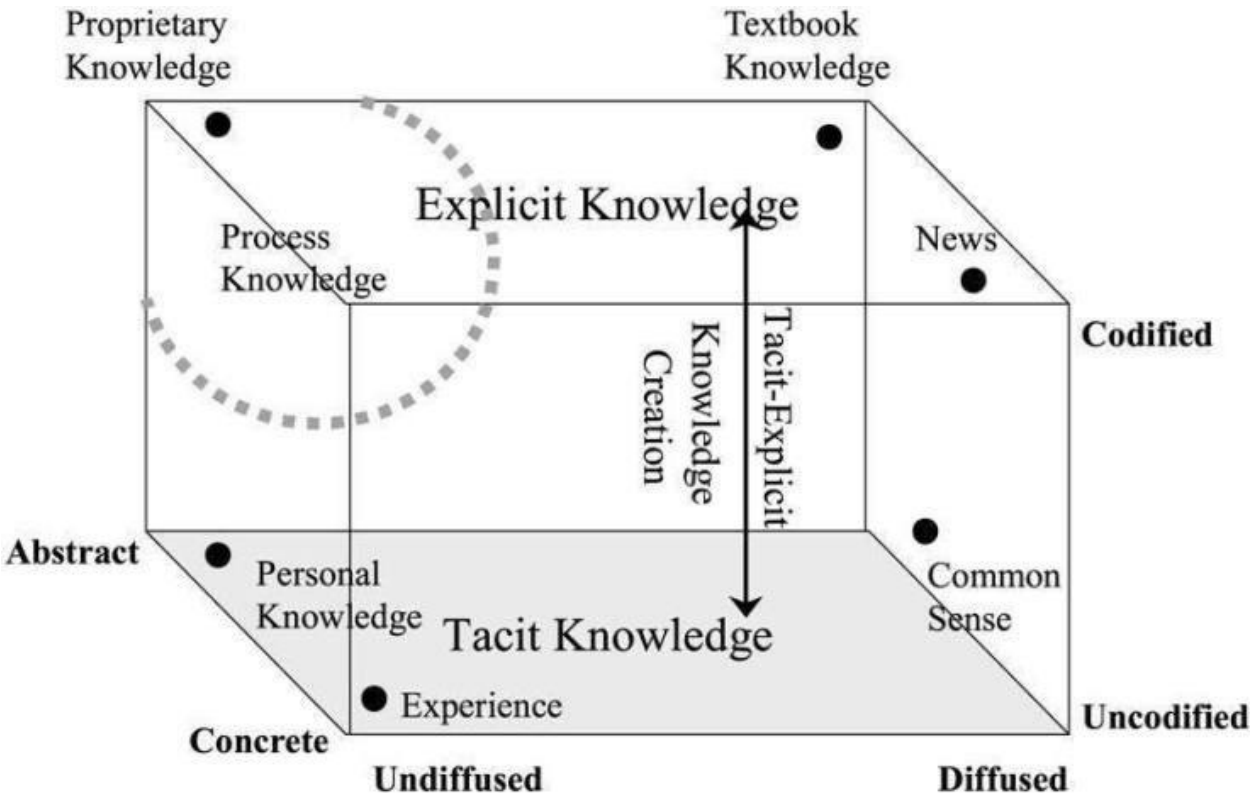

Fig. 4. Knowledge space model

In addition, Siemieniuch C. E. (2004) proposes another framework for Knowledge Lifecycle Management (KLM) called CLEVER (Cross Sectoral Learning in the Virtual Enterprise). The aim if the framework was stated as the following:

To clarify what are currently well-defined knowledge management problems into a set of specific knowledge management issues, set within a business context in order to:

- provide appropriate and relevant processes for people in the organization to solve the identified knowledge management problems . . . by
- defining the knowledge management problem and linking it to business drivers/goals . . . and
- creating the desired characteristics of the "to be" knowledge management solution . . . and
- identifying the critical migration paths to achieve the "to be" model . . . and
- selecting appropriate knowledge management process(es) to use on those paths [34].

The framework is split into four main stages which guide users through the KLM issues. The overall structure of the process framework is:

- **Stage 1: The problem definition template**. Defines the overall knowledge management problem within a business context, and corresponds to which of Boisot's first four

processes is to be addressed, and its context. **Outcome**: Clarification of the knowledge management problem and distillation of a set of knowledge management issues from the overall problem.

- **Stage 2: Overview of "to be" knowledge management solution**. Identifies where the company wants to be on a range of generic knowledge dimensions and highlights problem areas on which the company should focus. In effect, this defines the end point for the current problem on Boisot's social learning cycle. **Outcome**: Set of concerns or specific knowledge management components of the overall problem which should be addressed.
- **Stage 3: Critical migration paths.** Identifies critical migration paths for each specific knowledge management problem (or dimension of interest) – the set of management actions that need to be undertaken to obviate or ameliorate the identified problem. **Outcome**: Set of key migration paths for each specific knowledge management problem and overall set of migration paths for the whole KM problem identified.
- **Stage 4: Appropriate knowledge management processes.** Ensures that the organization is in a position to implement KM process(es) and to select the appropriate KM process to move along each chosen migration path. **Outcome**: Process available whereby the organization can check that it is in a position to implement knowledge management and set of appropriate KM process(es), which, when tailored to a particular organizations need, will address the stated knowledge management problems [34].

Knowledge management systems in various notations, forms and with different levels of detail have been developing for decades. Currently, many enterprises are using KMS. However, according to Zhang, Q. et. al (2010) the most studies focus on the details of technology, instead of management mode. In their paper, authors aim at creating a new KMS framework based on user innovation, employing ontology and knowledge reusing technologies.

With the creation of Artificial Intelligence, **ontology** became a philosophical category, and the artificial intelligence community gave it a new definition. Studer [36] introduced the definition of ontology as a "shared conceptual model of formal specification", which is now widely recognized. In practice, the five-body-array is commonly used to describe ontology: concepts or classes, relations, functions, axioms, and examples [35]. In the five-body-array, relation is the soul of ontology. The basis of the knowledge management base on ontology is building a good linked domain ontology base. The synonymous relation, appositive relation, hyponymy relation, composition relation, causality, and noun-modified relation [33] are examples of ontology relations that express limitations, contact, or a new relationship between concepts. Various relations can coherently link every type of knowledge node and form a network of knowledge

relations based on ontology, which can then be used to discover the correct knowledge node via relative path. In the paper by Zhang, J. et. al (2011) the network of knowledge relations is split into two sections in this paper: primary and secondary relationships between ontologies. The first relation describes all words regarding specific fields and the ontology relationships between them; the second relation describes the external terms of other fields that connect the terms of the primary ontology relations.

Zhang, J (2011) puts forward a model of multi-ontology bases about knowledge organization, this model is to establish unitary knowledge base respectively, use the basic characters of ontology and the relations described above that realize the interconnection of multi-ontology bases, and finally form a knowledge network, as it shown in Fig. 5.

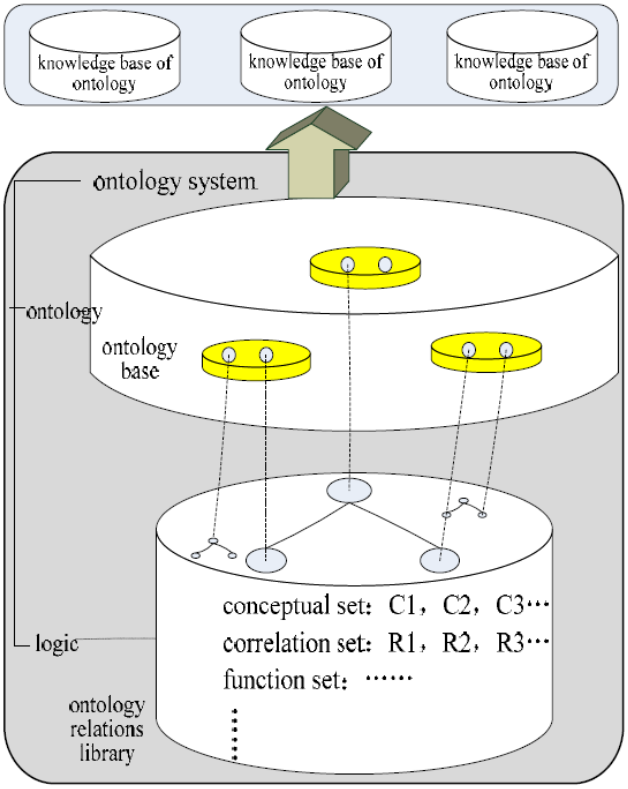

Fig. 5. Ontology knowledge organization model [41]

Ontology aims at capturing common knowledge in specific fields and provision of a common understanding of knowledge in these areas while realizing the reasoning of domain knowledge. Enterprise Ontology is currently a high-coupling system which structure is built into a conceptual network with complicated correlation. Unfortunately, because of the high cost and poor effectiveness, maintaining or reusing single component for such ontology is challenging. As a result, the modular ontology technology is used to solve the problem.

The main idea of UI-KMS framework illustrated at Figure 6 is the user-driven, high-level innovation with close user participation. The various flaws of traditional KMS are overcome, while user creativity makes innovation democratic. On the one hand, UI-KMS clearly depicts user pulling process (Push) in accordance with business process, assists user in identifying and capturing domain knowledge, and creates atom ontology to quickly represent domain ontology model based on domain ontology design. UI-KMS, on the other hand, presents a use-driven pull process in accordance with the needs of individual services, assists users in retrieving and reusing service components, and reconstructs services ontology to describe needed services quickly through services component reuse. In other words, the user is both the originator and the true end user of ontology. It is critical that the user has two distinct statuses. The former indicates that knowledge can be described as atom ontology, with the promise of process standardization in ontology design; the latter indicates that services can be re-deployed by users to maintain a high level of flexibility in matching inner services to the external environment, even when significant change has occurred outside.

Framework consists of five layers [42]:

1) **Expression layer.** The interface between user and system, that provides user-friendly man-machine connection.
2) **Knowledge service layer.** Series of independent service modules set in advance.
3) **Service ontology layer.** The modularization process of services knowledge with functionality containing decomposition, expression, retrieval, evaluation and reconstruction of special service.
4) **Domain ontology layer.** Represents domain ontology knowledge modular process, which main function is to express, define and store the domain knowledge.
5) **Knowledge resources layer**. The principal task of it is to collect, store and maintain the information from knowledge resource. This layer provides all needed knowledge for KMS, including structured, semi-structured and unstructured knowledge.

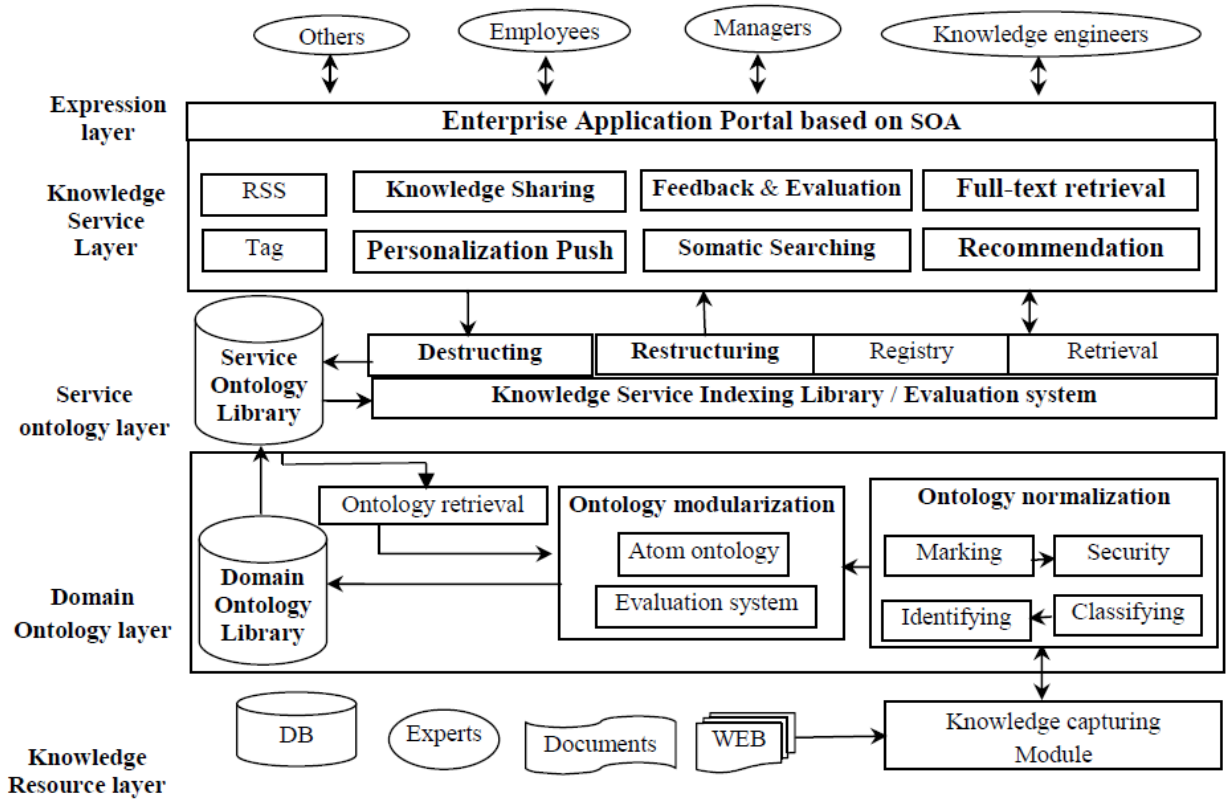

Fig. 6. KMS framework based on User innovation [42]

This framework enhances company's processes yet brings new challenges to the management to solve in order to succeed in its implementation:

- **Environment constructing.** It is important to build a learning organization with the incentive mechanism.
- **Technology supporting.** IT department have to support transformation by building domain and service atomic ontology. In addition, they should actively support user innovation process to increase end user satisfaction.
- **Evaluation management.** IT department should ditch low effect atom ontology, expand fine ontology and deepen the company-level knowledge understanding.

Another ontology-based framework proposed by Zhang, J. et. al (2011) is divided into three parts for the purpose of function realization mentioned above. They are **acquisition** of knowledge, **storage** of knowledge, and **reuse** of knowledge. Knowledge mining, knowledge representation and knowledge connection link the whole process, whose core notion is ontology. The framework of ontology-based KMS designed is depicted at Figure 7.

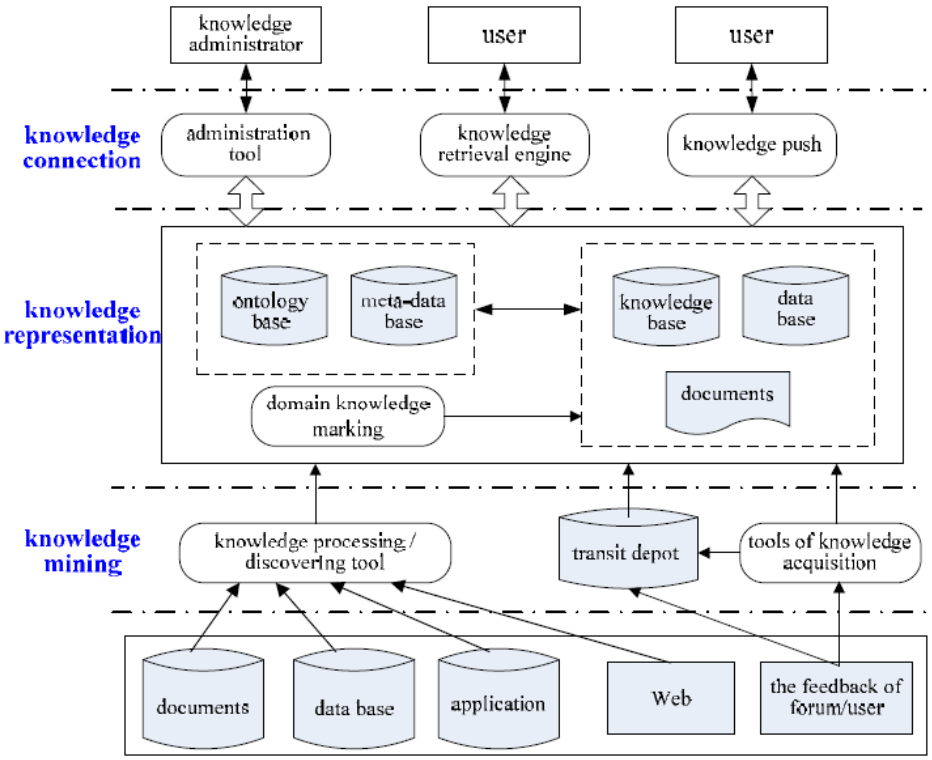

Fig. 7. Ontology- based knowledge management system framework [41]

Ontology is tightly related to another concept - **Knowledge Graphs (KG) -** large networks of entities and relationships relevant to a specific domain, where each node of the graph is an entity and each edge is a semantic relationship connecting two different entities. KGs are explicitly designed to capture the knowledge within domains, integrating and linking data from different phenomena, or different types of representation [20].

EXplainable Artificial Intelligence (XAI) is the field of research where mathematicians, computer scientists and software engineers design, develop and test techniques for making AI systems more transparent and comprehensible by its stakeholders [18]. In Figure 8 authors represent a schematic graph that summarizes the role of semantic technologies for XAI.

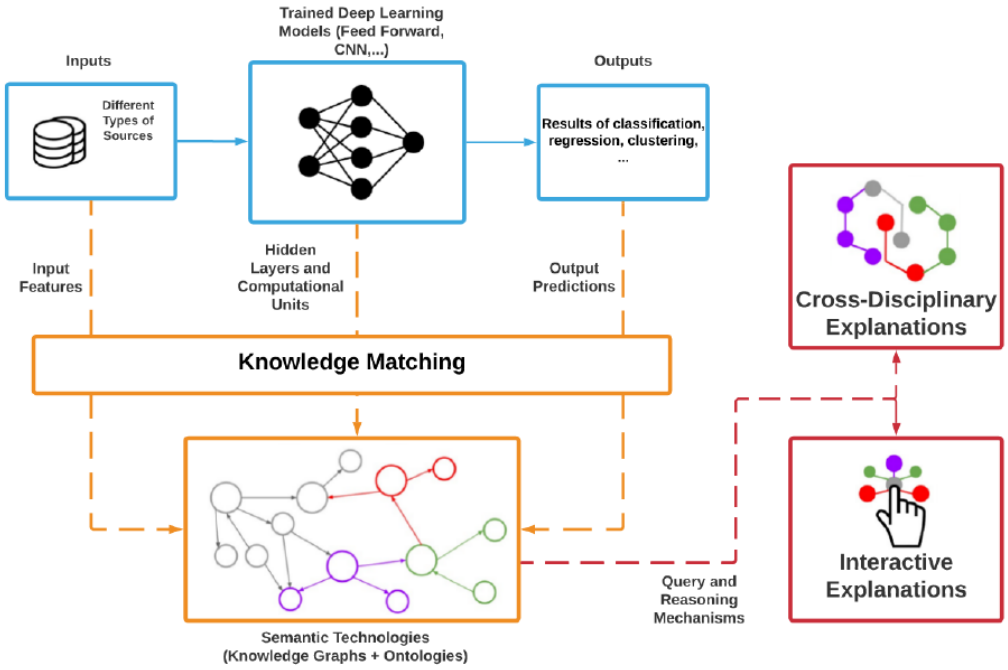

Fig. 8. Schematic representation of an explainable AI system that integrates semantic technologies into deep learning models.

The traditional pipeline of an AI system is depicted with the blue color. The Knowledge Matching process of deep learning components with Knowledge Graphs (KGs) and ontologies is depicted with orange color. Cross-Disciplinary and Interactive Explanations enabled by query and reasoning mechanisms are depicted with the red color. Knowledge matching of deep learning components, such as input features, hidden units and layers, and output predictions, with KGs and ontology components can make the internal workings of algorithms more transparent and comprehensible. In addition, query and reasoning mechanisms of KGs and ontologies can enable advanced explanations, such as cross-disciplinary and interactive explanations.

1.3 Review of the literature on the topic of Artificial Intelligence

In terms of such an innovative research area as Artificial Intelligence, one notable framework was the Innovation-Automation-Strategy cycle described by Makowski, P. and Kajikawa, Y. (2021). It focuses on the Research & Development process, on the identification and implementation of innovations. The authors of this article are aimed at the discussion of the possibility of automation of innovation process in organization and would present a perspective on the role of innovation studies that draws systematic consequences of automation. As for the first, their hypothesis is that given the current success and omnipresence of technology there are

reasons to perceive the societal process of innovation as highly automatized. As for the second, to draw actionable consequences of this idea they propose to reconsider the character and role of innovation management and innovation studies in a new perspective. It is believed that current knowledge in these areas is developed enough to be examined in what they call the Innovation-Automation-Strategy (IAS) cycle.

To obtain suitable context for the IAS cycle, they first introduce integrated framework for the process of innovation. It is worth noting that the purpose of this research paper is not to provide a complex literature review, but to present a blueprint of unit process in the innovation process. The authors provided their own diagram of the innovation process (Fig. 9), which they subsequently took apart and explained each element.

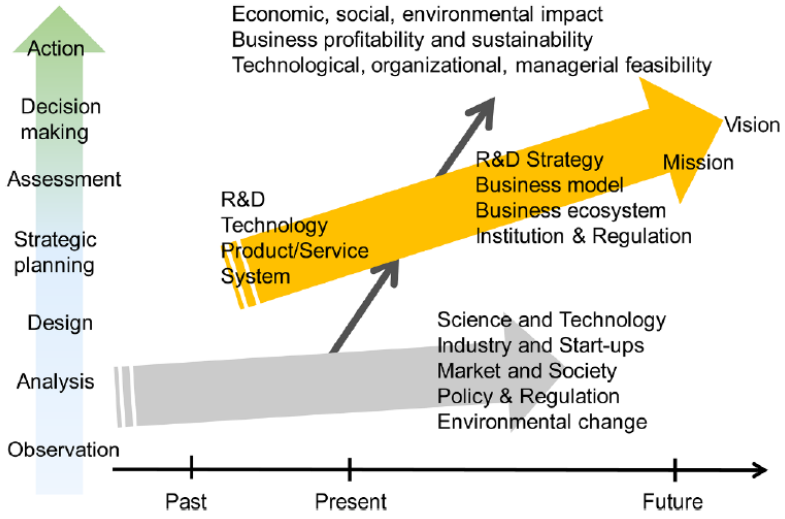

Fig. 9. Unit process in innovation process

Observation includes monitoring of multi-information resources and retrospective data collection. *Analysis* is based on past and present data. One of analyses is forecasting future trend based on existing data and a development of suitable scenario. *Design* does not mean only industrial design of products and services. It includes design of system where products and services are embedded, technology enabling and manufacturing products and services, R&D realizing technology if needed. *Strategy and planning* give feasibility that design will implement as business. Strategy is needed at various levels within an organization from R&D strategy, business strategy and business model, corporate strategy, strategy in business ecosystem [10]. *Assessment* of strategy and planning is important for comprehending of technological, organizational, managerial feasibilities, business profitability and sustainability and environmental, economic and social impacts. Finally, *decision making* reflects power structure in each organization. If machine

learning has more predictive power than experts' judgements, in a naive sense, decision-making based on AI is beneficial for the organization and society.

The **IAS cycle** (definition) (Fig. 10) is a simplified model of multi-scale process in which innovation is profitably transferred from state-of-the-art emergent technologies to technology-sensitive organizational processes where it gives raise to deliberate, strategic management innovation and it further is diffused to new emergent technologies. The whole process is entangled with social change. The IAS cycle implies an impact on many aspects.

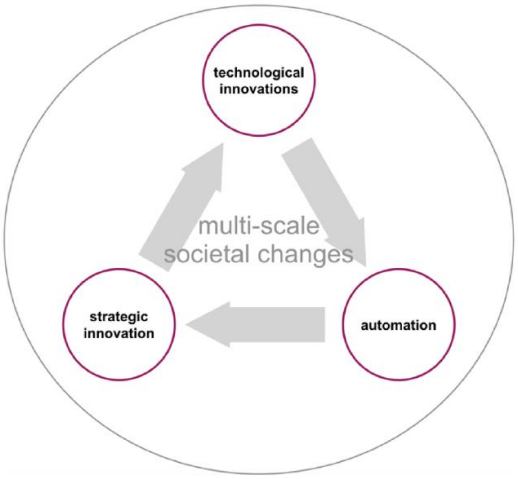

Fig. 10. The IAS cycle

The perspective associated with the IAS cycle has several implications, among which the following three are of key importance. First, it implies that automation of organizational processes de facto precedes managerial innovation: emerging technologies first permeate organizational structures, practices and capabilities, changing business processes, and then they trigger strategic innovation mechanisms. Automation becomes a prerequisite for strategic innovation. Second, although disruptive impacts on existing business models, value chains and identities can always occur, the IAS cycle is based on the assumption that innovation spreads smoothly. In other words, innovation is socially and economically beneficial at every stage of the cycle to the extent that any instances of disruption do not negate the spread of automation. The smoothness of diffusion can be perceived as an inherent feature of the cycle. Third, if we adopt the view that organizations should strategically support innovation ("culture of innovation"), the IAS cycle shows that automation is just as important in the diffusion of innovation diffusion of innovation than consciously "managing" innovation at the micro level of organizational practices. In this sense, automation not only enhances innovation, but also changes the view of innovation management.

Another framework related to AI implementation (Fig. 11) is proposed by Bhattacharya, P. (2020). The author focuses on knowledge and data security issues in the implementation of artificial intelligence in company business processes. This paper examines in detail the application of artificial intelligence technologies to organizational processes and security findings for such institutions, with a particular focus on decision-making processes in a business context. The importance of this study is that it offers a new procedural framework that examines the security implications for organizational decision-making using artificial intelligence systems. The analysis is based on a combination of the literature on organizational decision making and the security concerns of AI technologies. However, there is a need to empirically test this new model using various case studies.

Artificial intelligence technologies, in particular neural networks, continue to gain popularity in supporting financial decisions in business [1]. In particular, it has been used to a great extent for predicting failure, securities market valuation, and debt, used in several phases of financial decision-making, such as financial health assessment, debt risk assessment, and securities market assessment.

The increased use of artificial intelligence such as Wealthfront and Betterment creates the risk of replacing financial advisors, given their ability to do all stock trading. With the reliance on genetic evolution and probabilistic logic, the use of AI in financial decision-making continues to gain traction [12]. This influence continues to permeate various aspects of business, with industrial collaboration is demonstrating an increasing reliance on AI systems to manage drilling processes. With AI systems, engineers use drilling parameters and receive warnings of potential risks that are vital to their success.

Meanwhile, there are safety implications associated with such artificial intelligence systems. For example, there is considerable concern about how to isolate problems that arise while maintaining system properties.

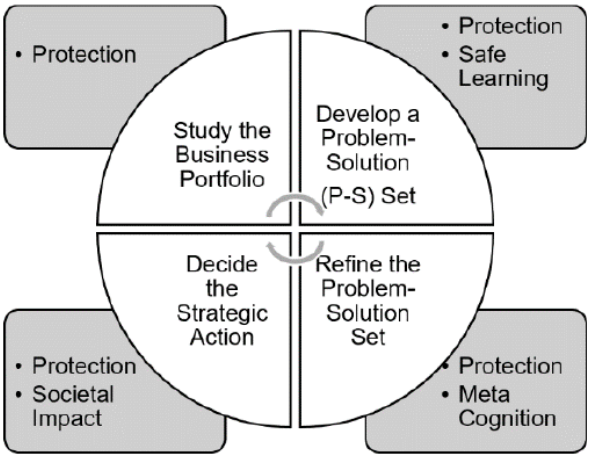

Fig. 11. A model to address the security threats of using AI to enable business decision making [8]

There are four main challenges due to the use of AI in business decision-making including protection, safe learning, meta-cognition, and societal impact. *Protection* talks about how to model AIs to overcome aggressive environment and challenges. It entails the development of sandboxed AIs that are protected from threats. *Safe Learning* provides that AIs must ensure it is error-free in its learning processes to avoid lethal mistakes during the stage of learning. *Meta-cognition* involves the ability of the system to address logical uncertain events resulting in strange paradoxes. *Societal Impact* will involve substantial economic, military, legal, and political effects, and all these must not be detrimental.

All the aforementioned actions are wrapped around the main cycle, which consists of four parts. *Studying the business portfolio* means learning the business portfolio, its national and global current markets, the product-service sphere, and customer characteristics as well as other features. *Development of problem-Solution (P-S) Set* implies determination of as much problem-solutions sets as possible, where the aim is to point out and give particular suggestions for the problem. AI has the potential and ability to contribute extensively through the application of the system to identify different solutions to emerging problems. *Refining of the Problem-Solution Set* entails fine-tuning of Problem-Solution Set by detecting further optional solutions by using AI applications. AI in this stage is considered as a professional who can help in giving direction and advice on what other alternative solutions are available. Finally, *deciding on the strategic action* is the final decision about the process of action to be taken which should involve human intervention. The human agents, in this case, rely on their experiences in regards to political, interpersonal, and or personal circumstances to make rational judgements.

Regarding the symbiosis of AI and KM, Sundaresan S. (2021) in his paper synthesized the elements from different parts of the relevant literature and develop a unified framework consisting of three dimensions of AI systems, three knowledge management (KM) activities and two types of AI–human interactions. Based on this framework (Fig. 12-13), the authors summarize the primary use cases supported by AI-enabled knowledge management systems (KMS) and compare them with the traditional KMS use cases. The authors find that a single type of AI system is insufficient to support the increasingly complex nature of knowledge workers' activities, manifested in three dimensions – process, engagement and content; a tailored AI system should be developed to support knowledge workers in their unique roles and processes.

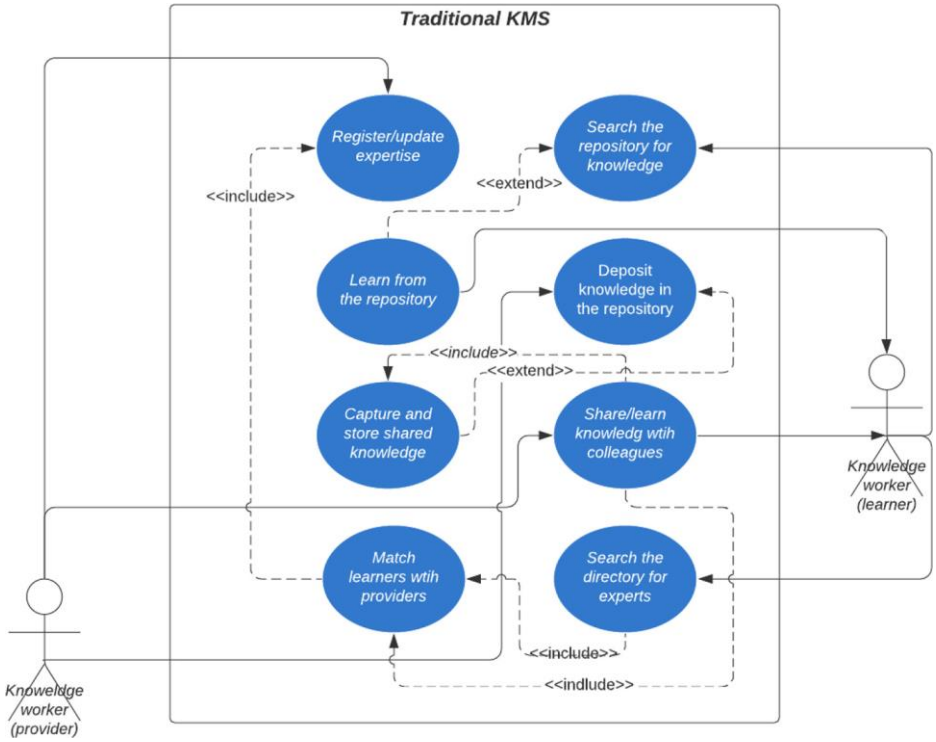

Fig. 12. Use-case diagram of traditional KMS

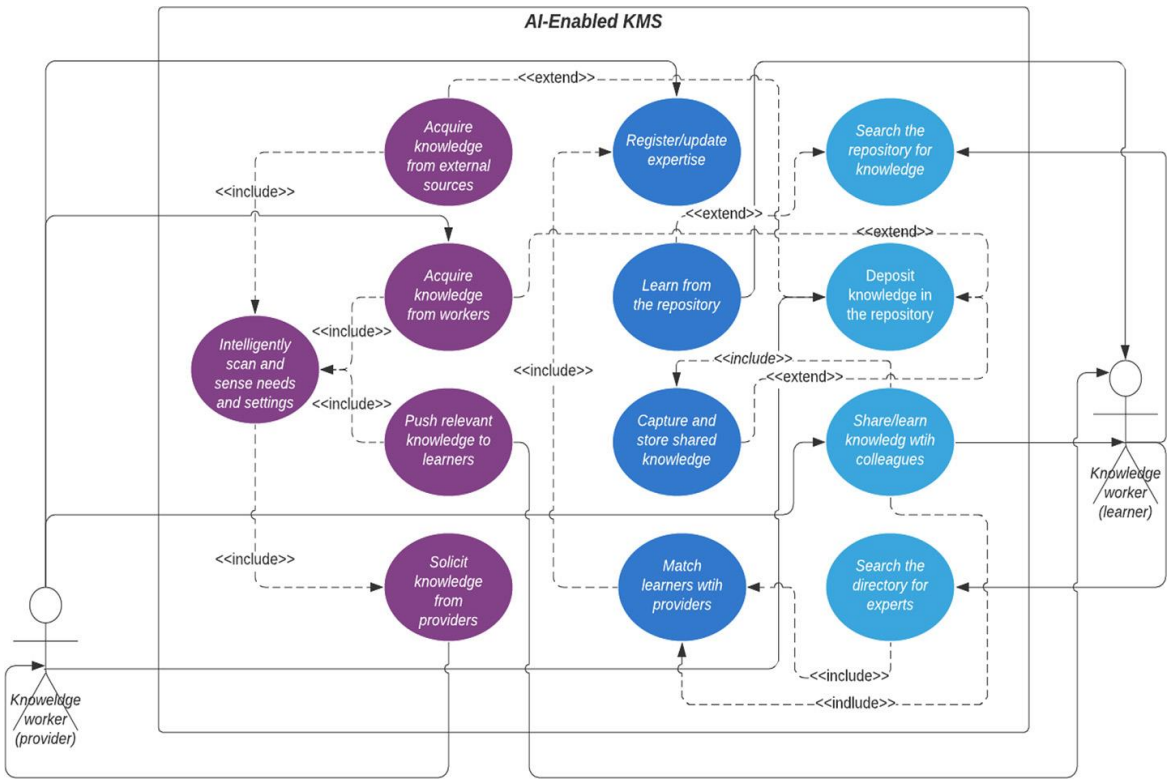

Fig. 13. Use-case diagram of AI-enabled KMS

In addition, Fowler A. (2000) in his paper has evaluated the phenomenon of knowledge management (KM) and its relationship to the artificial intelligence (AI) technologies of knowledge-based systems, case-based reasoning and neural networks. Then, he has established the **knowledge value-chain** (KVC) concept and developed it into a closed loop knowledge activity cycle. This is then was linked to Nonaka's knowledge spiral and related concepts. Using this framework, applied within the context of the core business processes underpinning a modern "knowledge company" that is operating at the forefront of computer networking technology, he has researched the potential application of AI. In general, this study The study discusses both the potential and the limitations of AI technologies in terms of their capability to support the Knowledge Management process [17].

Regarding types of knowledge, Fowler did not stop on tacit and explicit knowledge. In Figure 14 there are displayed some other useful categorizations including **declarative**, **procedural**, **specific** and **abstract**. For example, specific knowledge is associated with inductive reasoning whereas abstract knowledge tends to be associated more with the deductive form. A taxonomy of knowledge may thereby be envisioned in which the categories are portrayed as being dispersed as shown. Notably in some cases, overlapping and clustering of categories is opt to be. For example, the category of logic, which subdivides entities according to whether they are viewed as objects, attributes or values, may be generally applicable to all of the other categories.

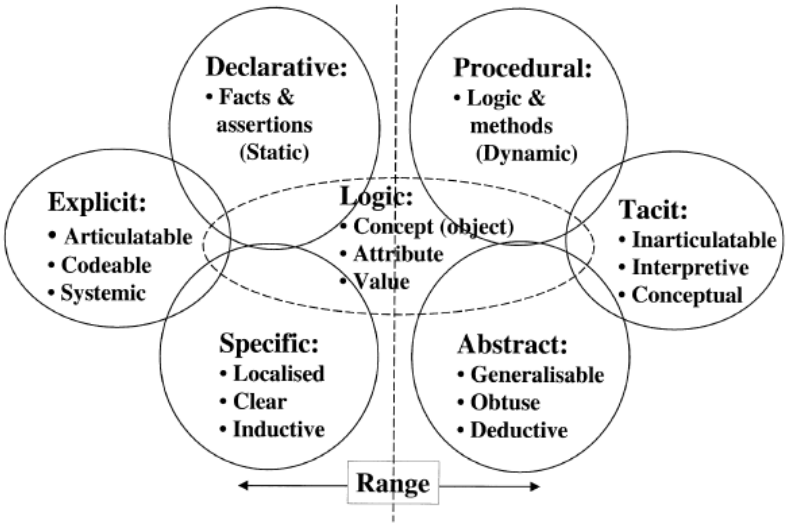

Fig. 14. Fowler's taxonomy of knowledge

Neural networks have advantages over other computer systems, such as traditional Knowledge-Based Expert Systems (KBES) (Figure 15), in that they may generalize, abstract, and possibly even display apparent intuition with insufficient information [32, 34, 38] They are made up of multiple nodes that are akin to the axons of the biological brain in certain ways, and are linked together at the interface synapses by weighted information linkages (similar to the dendrites of the brain). As needed, fuzzy logic could be incorporated onto this structure. As a result, the output is a complicated function of all of the inputs and their interactions.

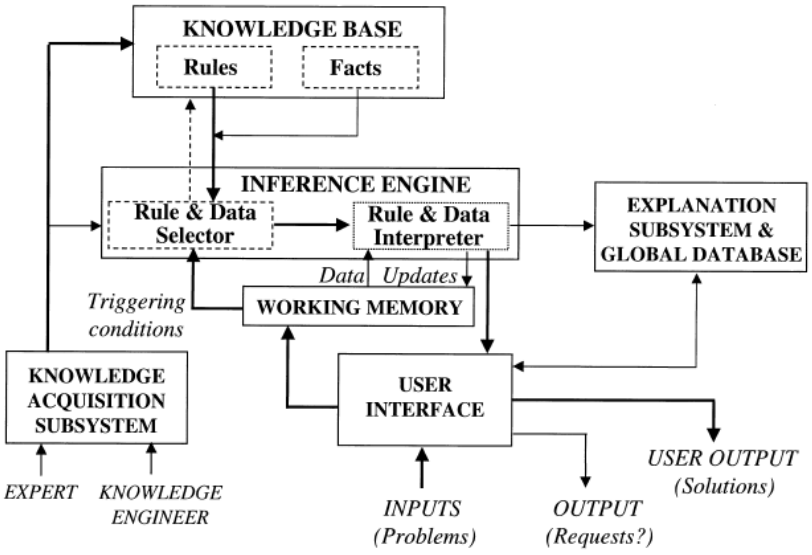

Fig. 15. The basic architecture of a knowledge-based expert system.

Figure 16 depicts the principles in a much more basic schematic format. The system's primary goal is to provide outputs, such as decisions, that are as good as or better than what an expert human would make given the same set of input data. This is accomplished through repeated

learning cycles in which the system is fed a set of known inputs and outputs. The strength or weightings associated with the links between nodes are then progressively changed by internal optimization methods that strive to minimize the error between the 'ideal response' and the answer currently given by the neural net. This process is continued with several sets of training data until the output performance is judged to be accurate and consistent. At this point, the “trained” system can be used to make or advise on future decisions based on similar sorts of data input.

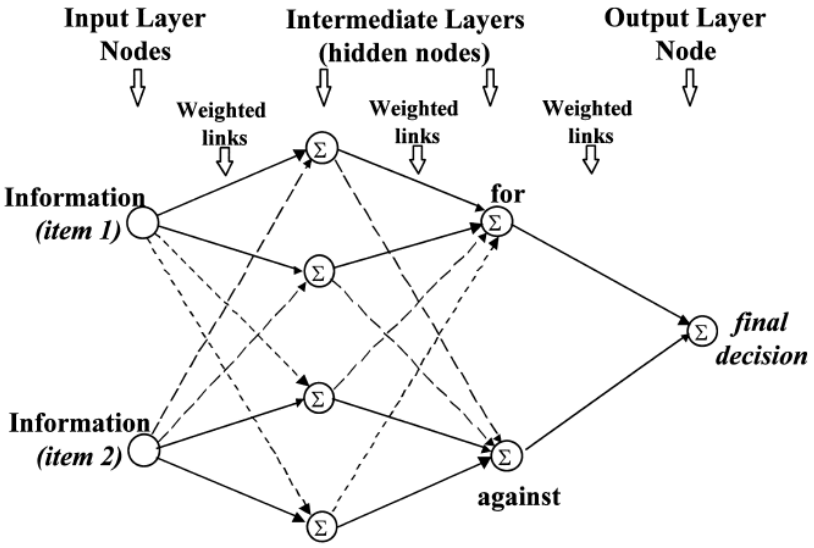

Fig. 16. The basic architecture of a neural-net-based expert system.

As a result, this approach to AI differs significantly from that which underpins rule or frame-based expert systems, because there is no embedded explicit knowledge base or related rule set, only a collection of assumed empirically derived data associations. As a result, it is not claimed that NNs are aware of certain structures or situations. Their sole purpose is to give a “black-box” transformation of incoming data into recommendations or action based on prior “learning experiences”.

1.4 Research Gap

The done research gave the understanding on what are the main existing trends and frameworks in the areas of Informational Technologies, Knowledge Management and Artificial Intelligence. What is more, it provided me with understanding, what is lacking in these knowledge areas. In particular, there are indeed many research on the models, schemes and frameworks, yet most of articles are based on outdated concepts (some of which are even from 1950s). In addition, researches about Knowledge Management and Artificial Intelligence are primarily done by specialists and scientists from USA, India, China, Japan and other well-developed countries.

Russian scientific community, in turn, is focusing less on the development and implementation of these concepts, leaving the market only with some papers, shadowed by pop journal articles, reports and foreign software. This brings another gap – overall lagging of the Russian market behind others in terms of the level of research in these areas. Last but not least, even though there are researches about numerous concepts and approaches, only the minor part of them include approbation of the proposed concept on real life examples, leaving readers with abstract thoughts and definitions. This brings us to another gap – lack of testing of the suggested solutions.

Summary of Chapter 1

In conclusion, it is important to say that even though the topics of IT, Knowledge management and Artificial Intelligence have been evolving for decades, there are several significant key definitions, models and frameworks to guide the process of business process optimization through the digitalization, implementation of KMS and AI. Each focuses on a different aspect, be it security, automation, decision making, knowledge creation and delivery or innovation process. Each model, when adapted to the needs of a particular business, will help deliver sustainable benefits. Nevertheless, an assessment of the gap between business needs and the proposals of the scientific world is required, as well as validation in conjunction with a list of recommendations, which is what this paper will focus on.

Chapter 2. CASE STUDY

2.1 Company description

For my master thesis, I have chosen Russian company called “Way2Win Group”. Incorporation form and the name of the company is Individual Entrepreneur Petr Tolochkov. This IT company offers the turnkey development of various innovative digital products and software using cutting edge technologies. The main areas of the company’s work are artificial intelligence and augmented or virtual reality [39].

Way2Win Group is a Russian private company, which operates locally and have already started expanding its customer network to global market. It helps companies from different spheres such as HR, EdTech, Pharma, FMCG to boost their brand image and sales with the help of modern technologies and innovations. In addition, it works with clients from governmental sector. The company was found in 2017 and already has more than a hundred successful projects in its portfolio. Main office is located in Moscow, while representatives are from various cities: Moscow, Saint-Petersburg, Omsk, Ekaterinburg. This is due to the remote format of work in the company.

Company offers its customers a wide range of products and services depending on their needs: data analysis and parcing, forecasting analytics, recommendation systems, chat-bots for technical and customer support as well as for corporate education programs and sales automation. When it comes to augmented reality, company can prepare fully interactive product visualizations, 2D and 3D videos, virtual tours of important facilities or virtual conference stands and presentations for summits and personal visits.

Because Way2Win Group is not a public company, it does not have any publicly available financial reports or values. Nevertheless, from the inside it can be seen that by the end of 2021 the company revenue was approximately 30 million rubles, which is almost 90% higher than the same value last year.

Virtual reality as it is now has started developing in Russia for just about a decade, which means that the market is not at its stable position. Many companies emerge and disappear, giving space for new and more promising ones.

According to TAdviser, in 2020 Russian VR market has reached 1.4 bln rub, with 16% increase comparing to the last year. The study notes that the main demand for virtual and augmented reality solutions in Russia is formed by commercial organizations. More than half of

the projects in 2020 came from manufacturing enterprises and companies in the fuel and energy sector.

Industrial AR/VR projects in Russia are primarily focused on supporting mass training in terms of developing soft skills: simulators and simulators for training equipment specialists (operators, repairmen), pilots, digital instructions, as well as remote expertise.

2020-2021 has been an incredibly challenging year for many small and medium-sized businesses, including VR/AR agencies. The low dynamics in the VR segment development is due to the consequences of the COVID-19 coronavirus pandemic, due to which there have been far fewer holiday and other events, as well as marketing initiatives and entertainment content projects [43].

According to TMT Consulting, in 2020 market had 70% in B2B and 20% in B2G, which correlated with the fact that by the end of 2020 was at the initial stage of development, most of it was formed by individual projects. At the same time, the number of such projects is growing, and an extensive pool of developers has formed, including software and custom solutions developers and hardware creators - from small studios to subdivisions in leading domestic system integrators.

While there are dozens of similar companies, Way2Win Group has taken its place because of its special skills and competencies. The company has a very deep understanding of the pharmaceutical industry, which sets it apart from its competitors in the eyes of potential customers. Company's clients – pharmaceutical companies: Pfizer, Gilead, Bayer, Novartis, Novo Nordisk etc.; companies from FMCG, EdTech and governmental sectors: Rostelecom, RZD, Splat, University of Copenhagen etc.

In addition, one of the main factors to consider in such intense competitive environment is the importance of media activity and customer feedback. Nowadays, it is no longer enough to perform professionally well, but it is necessary to tell the story, and not only to tell it, but to try to make it interesting, involving and converging. Openness and activity in the media largely determine success. In terms of media activity, Petr Tolochkov, Way2Win Group CEO, has pitched on many conferences, television and wrote several articles about virtual and augmented reality, artificial intelligence and other cutting edge technologies immersing into Russian businesses nowadays and in the future. Company is present on such platforms as LinkedIn, Facebook, VC.ru is expanding its networking into international UGC platforms.

Because this IT company is rather young, the organizational structure of the company is traditional hierarchical with organic features. Each project involves each department at certain

stage, thus, subcontractors and clients are involved into communication and work with a team that forms specifically for current task. (Figure 17).

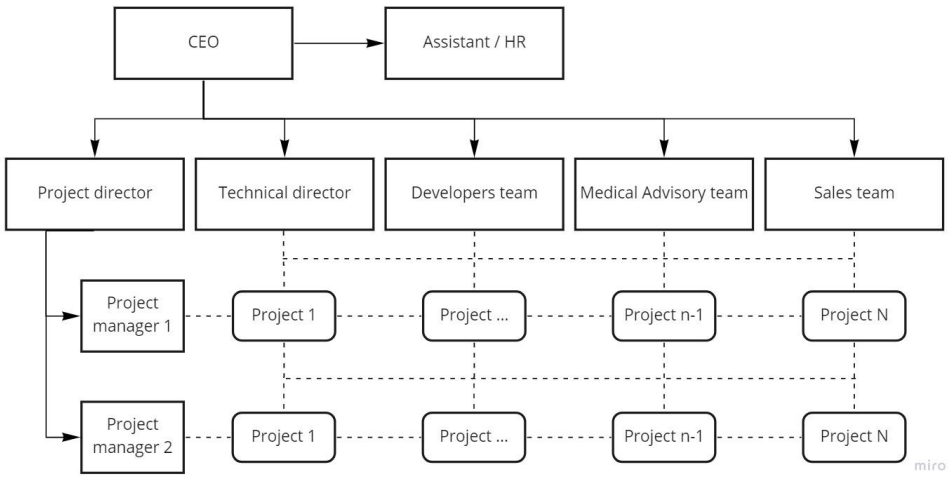

Fig. 17. Organizational structure of Way2Win Group

For now, the most usable inside communication channel is Telegram, where all the coordination with subcontractors and employees is done. On the other hand, communications and meetings with customers are done via Outlook and Zoom.

Petr Tolochkov, General Director is responsible for new projects acquiring, pitching on conferences, business development and many other operational tasks (due to rather small size of the company – 23 people plus subcontractors and freelancers). Assistant and HR-manager is responsible for a wide spectrum of tasks, one of which – searching and hiring for subcontractors for specific projects and new members of full-time team. Project Director and Technical Director are responsible for project coordination, process management and high-level communication tasks. Developers' team is responsible for direct development and support of our solutions. Medical advisors are consulting us upon medical terms and concepts, bringing our products to the next level of accuracy. Finally, our Sales team are visiting summits, conferences and working on acquiring new potential customers and projects, which would later be delivered to project managers.

2.2 Research methodologies

My methodology for analyzing the current situation is based on a systematic approach. I developed questionnaires that were sent to company employees, and in addition, I relied on the analysis of existing documents and other sources of knowledge to assess the current knowledge

base. Thus, to gather the necessary information about company's knowledge, the following questions were opt to answer:

1. What is your role in the company?
    a. CEO
    b. Account Director
    c. Technical Director
    d. HR Manager
    e. Project Manager
    f. Sales Manager
    g. Developer
    h. Designer
    i. Medical Advisor
    j. Other (please, specify)
2. How often do you work with files?
    a. Never
    b. Once in a month
    c. Once in a week
    d. Several times per week
    e. Every day
3. What kind of files do you work with? (open question)
4. Where do you store work files?
    a. Personal computer
    b. Yandex Disk
    c. Google Drive
    d. ClickUp
    e. AMO CRM
    f. Telegram chats
    g. E-mails
    h. I print them out
    i. Other (please, specify)
5. How many files do you create/change/get when working on a project?
    a. 0-5
    b. 6-10
    c. 10-15

    d. 15+
6. How often do you need to recall for some old files (or previous versions) to adapt, change or look up for some information?
    a. Never
    b. Once in a month
    c. Once in a week
    d. Several times per week
    e. Every day
7. Have you faced any issues when you could not find necessary file? Please, describe the situation. (open question)
8. If you mentioned something in the previous question, please, specify, what or who helped you with this problem's solution?
    a. Colleague
    b. I found it myself
9. What accounts do you have specifically for your work? Please, list them. (open question)
10. If there would be the unified knowledge base implemented in the company's network, would you switch to it and use?
    a. Yes, absolutely!
    b. Maybe
    c. I don't think so
    d. Definitely not, I am full of systems in my daily routine

2.3 Analysis of the company and its current knowledge management system

In total, 100% of the employees have passed the questionnaire, and thus it can be concluded, that the company is lacking knowledge management in every aspect. All the information is stored in chunks on personal computers, emails, Google Drive folders, task-tracking software (ClickUp) and in printed versions. Most of employees (87%) have answered, that they would definitely switch to the unified KMS if there would be any.

In addition, the general classification of the company's knowledge has been acquired:

- Accounts
    - Development tools and boards
        - Zoom
        - Github
        - Golosa24

        - Shutterstock
    - Corporate network
        - Telegram
        - Google Workspace
        - Yandex Disk
        - Outlook
        - Yandex360
        - Google Drive
    - Media platforms
        - Company’s websites
        - Vc.ru
        - Youtube
    - Job boards
        - Behance
        - Dribble
        - upWork
        - hh.ru
- Documents
    - Frame contracts
    - Additional agreements
    - Applications
    - Bills
    - Reports
    - NDAs
    - Exclusivity letters
- Presentations
    - Commercial propositions
    - Posters, flyers
    - General selling presentations
        - AR photobooth
        - KOL hologram
        - Instagram AR
        - 2D/3D videos
        - Web3D
        - AR App

        - Cases
        - CLM
        - VR
- Projects
    - Gantt timelines
    - References
    - Figma designs
    - Budget tables
    - Spreadsheets
    - Voiceovers
    - Client’s brandings
    - Builds (archives, apps)
    - Technical requirements
    - Emails
    - Scripts
    - Briefs
    - Screenshots
- Media presence
    - Event reports
    - Articles
    - Conferences reports
    - Press-releases
- Branding
    - Logos
    - Naming
    - Brand fonts
    - Brand colors
    - Brand presentation templates
- Guides
    - Articles/Schemes
        - Project initiation guide
        - ClickUp guides
        - Presale guide
        - Onboarding guides
    - Videos/Webinar recordings

        - Account management
        - Communication
        - Lead generation
        - Process management
- File types
    - .docx
    - .xlsx
    - .mp4
    - .mp3
    - .wav
    - .pdf
    - .pptx
    - .png
    - .svg
    - .psd
    - .fbx
    - .3ds
    - .html
    - Figma boards
    - Google Docs
    - Google Sheets

Summary of Chapter 2

Way2Win as an IT company (rather small) with semi-organic corporate structure is already rather digitalized. Nevertheless, the results show that the company lacks any rigorous knowledge management system (which can be justified by the size and age of the firm). Dozens of file types, scattered by project and by date, documents of different orientation, templates, drafts, notes - all this is stored without any general organization, relying only on the internal organization of company employees. In doing so, they outlined their dissatisfaction with the current state of affairs and their desire to simplify and optimize the process of creating, collecting, storing, and transferring knowledge for their own and external needs.

Thus, using the theory of knowledge management, as well as the above frameworks, the solution to this problem can be the development into a framework for the knowledge management system with elements of artificial intelligence.

Chapter 3. DESIGNING A FRAMEWORK

3.1 Main components

According to Zhang, Q. (2011) and others, the gathered knowledge types (documented) can be divided into three basic types:

- **Structured** (comes mainly from enterprise business databases, passports, licenses, tax forms and other strictly formed documents with cells, checkboxes etc.); Example is in Figures 18-19.
- **Semi-structured** (stems from the technical documentations, descriptions about business workflow, background information about personnel and groups, diversified software systems, web on the knowledge on web); Example is in Figure 20.
- **Unstructured** (tacit knowledge from the experience of the experts, notes, texts, lists).

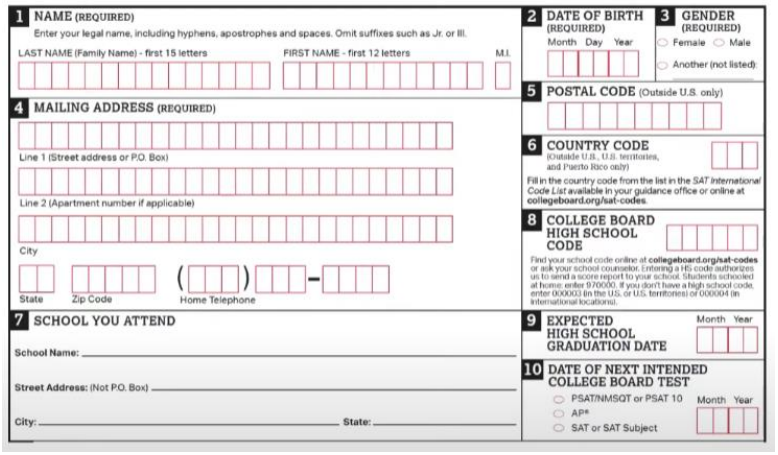

Fig. 18. Example №1 of the structured document

Fig. 19. Example №2 of the structured document

University Health Center

ED Physician Documentation- Addendum

Psychiatric screening exam with anxiety disorder

Patient: **WEST, SUZY** **MRN: 1234567** **FIN: 1012529**
Age: **55 years** Sex: **F** DOB: **6/2/1964**
Associated Diagnoses: **None**
Author: **JONES MD, FRED**

Basic Information
Time seen: Date & time 1/29/2020 17:13:00.
History source: Patient.
Arrival mode: Ambulance.
History limitation: None.
Additional information: None

History of Present Illness
The patient presents with psychiatric problem and anxiety. The onset was gradual. The course/duration of symptoms is fluctuating in intensity. Character of symptoms anxious. The degree of symptoms is minimal. Self injury: none. There are exacerbating factors including financial problems and housing problems. The relieving factor is medications(s). Risk factors consist of non-compliance. Prior episodes: occasional. Therapy today: none. Associated symptoms: none. Additional history: denies physical complaints at this time beyond anxiety.

Review of Systems
Constitutional symptoms: no fever.
Skin symptoms: Negative except as documented in HPI.
Eye symptoms: Negative except as documented in HPI.
Respiratory symptoms: no shortness of breath.
Cardiovascular symptoms: no chest pain.
Gastrointestinal symptoms: Negative except as documented in HPI.
Genitourinary symptoms: no dysuria.
Musculoskeletal symptoms: Negative except as documented in HPI.
Neurologic symptoms: Negative except as documented in HPI.
Psychiatric symptoms: Anxiety.
Endocrine symptoms: Negative except as documented in HPI.
Hematologic/Lymphatic symptoms: Negative except as documented in HPI.

Health Status
Allergies:
Allergic Reactions (Selected)
Severity Not Documented
Haldol- Distortion.
Penicillin- Rash.
Prolixin- Hallucination.
TEGretol- Rash..
Medications: clonazepam.

Past Medical/ Family/ Social History

PATIENT NAME: ***WEST, SUZY*** *MRN:* ***1234567*** *FIN:* ***1012529***
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Fig. 20. Example of the semi-structured document

History of Present Illness
The patient presents with psychiatric problem and anxiety. The onset was gradual. The course/duration of symptoms is fluctuating in intensity. Character of symptoms anxious. The degree of symptoms is minimal. Self injury: none. There are exacerbating factors including financial problems and housing problems. The relieving factor is medications(s). Risk factors consist of non-compliance. Prior episodes: occasional. Therapy today: none. Associated symptoms: none. Additional history: denies physical complaints at this time beyond anxiety.

Fig. 21. Example of unstructured document

To extract data from **structured** documents we could use so-called positional data extractor. This is the simplest solution, as we can predefine anchor points (by setting coordinates and area), where AI would look for necessary and already classified information and values.

When working with **semi-structured** documents we cannot be sure that the information will be in the same anchor point and its size will fit the anchor size. Moreover, we do not know at page the data could be. More common approach here is the Form (key/value) extractor. This extractor is the machine learning model that is trained to recognize the relationship between the keys and values. It works well, it is easy to configure, but they are not 100% accurate, so that some data elements could be missed. There are also extractors called "Table extractor" which are similar to Form extractors, but they pull the data out of tables (for example, from invoices).

Finally, when working on **unstructured** documents, the main shallow assumption we can make is the language of the words, grammatical structure and sometimes the domain of the document (for example, in Fig. 21 the domain is "anxiety"). In this case we use extractor called "Named-Entity Recognizer" (NER). This is a machine learning model as well, and is trained on a large text corpus to recognize specific types of terms of entities (people's names, places, dates, project names, company names, technology used).

3.2 Limitations and structure design

Currently machines are not as smart as we would like. There are certain limitations: they are highly domain constrained, reliant on big data, require complex learning models, only use flat arrays of input data and do not exploit data context. That is why another concept that is going to be implemented in the KMS framework is Knowledge Graphs. Recapping the definition by Heath, T., Bizer, C. (2011), **Knowledge Graphs (KG) -** large networks of entities and relationships relevant to a specific domain, where each node of the graph is an entity and each edge is a semantic relationship connecting two different entities. KGs are explicitly designed to capture the knowledge within domains, integrating and linking data from different phenomena, or different types of representation.

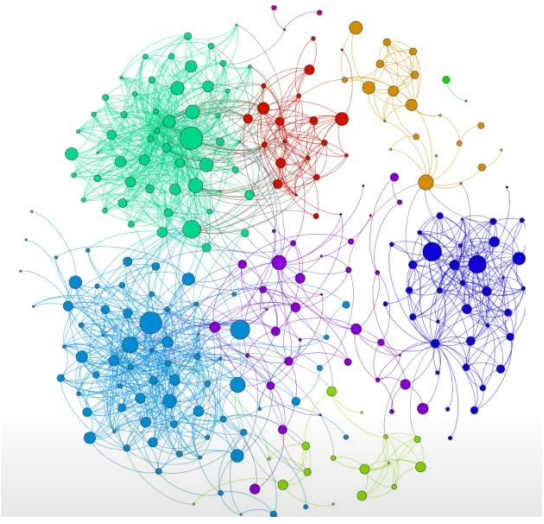

Fig. 22. Example of a knowledge graph [31]

Another concept to be implemented is **ontology**. Being the "shared conceptual model of formal specification", ontology can be represented with five-body-array [35]:

- Concepts or classes;
- Relations;
- Functions;
- Axioms;
- Examples.

In the five-body-array, relation is the soul of ontology. The basis of the knowledge management base on ontology is building a good linked domain ontology base (Figure 23). Among the examples of ontology relations that express limitations, contact, or a new relationship between concepts there are [33]:

- The synonymous relation;
- Appositive relation;
- Hyponymy relation;
- Composition relation;
- Causality;
- Noun-modified relation.

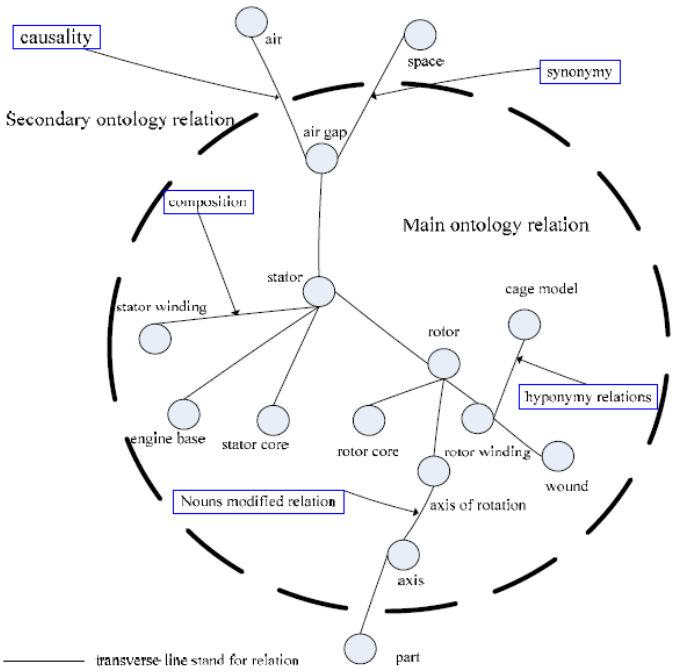

Fig. 23. Part of relation network (ontology) of motor's structure

Thus, in order to solve existing problems in knowledge management process in the target company and contribute to modern methodologies of KM, I propose the following framework illustrated in Figure 24. It is synthesized based on ideas presented by Zhang, Q., Peng, X. (2010), Zhang, J., Zhao, W., Xie, G., Chen, H. (2011) and Futia, G., Vetro, A. (2019).

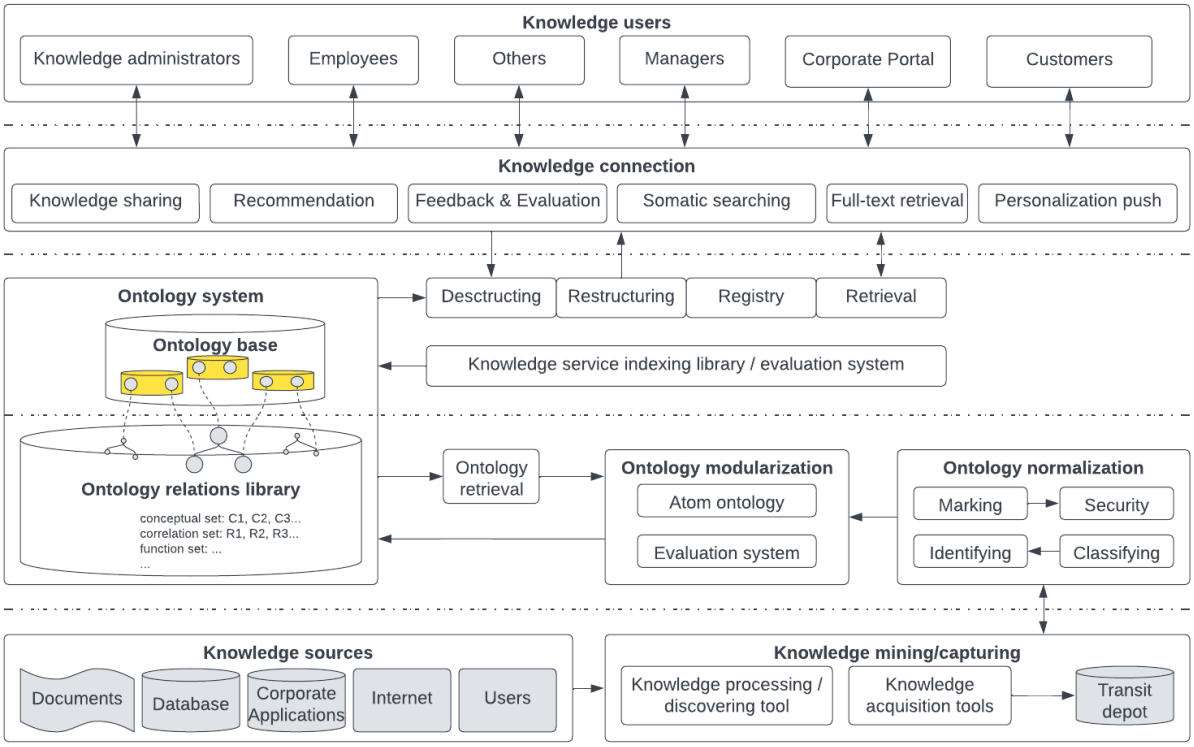

Fig. 24. Ontology-based KMS with the elements of AI

It consists of the following blocks, each realizing its own type of functionality:

- **Knowledge sources** layer. The primary function of the knowledge resource layer is to acquire, store, and maintain data from knowledge resources. This layer contains all of KMS's required knowledge, including structured, semi-structured, and unstructured data. Structured knowledge is primarily derived from enterprise business databases; semi-structured knowledge is derived from technical documentations, descriptions of business workflow, background information about individuals and groups, a variety of software systems, and web-based knowledge. Unstructured knowledge is primarily derived from experts' experience and other tacit knowledge.
- **Knowledge capturing** layer. The abstracting process based on the concept of ontology is known as knowledge acquisition. The procedure converts the essential knowledge, as well as semi-structured and unstructured data, into structured data. Furthermore, knowledge mining

enables knowledge sources, such as diverse data bases, documentations, applications, and Web sites, to be incorporated into the knowledge base after being processed by the Knowledge Discovery System (KDS) and other algorithms embodied in the knowledge processing tool. Other sources of knowledge, such as material from various forums and user input (which contains tacit knowledge), are first placed in the transit depot.

- **Domain ontology** layer. The domain ontology layer defines a domain ontology knowledge modular process that expresses, defines, and stores domain knowledge. The domain ontology layer divides the knowledge resources layer from the service ontology layer. As a result, any changes to the knowledge resources layer will have no effect on the service ontology, and system stability will be improved. There are three aspects to the domain ontology layer: ontology standardization, ontology modularization, and modular domain ontology.

  In essence, the ontology normalization procedure creates binary group knowledge-items (Meta-knowledge, Information). Information is known as the information set, while meta-knowledge is known as meta-knowledge sets. Following the capture of original knowledge, the ontology normalization procedure must be completed. The knowledge items will be generated in accordance with the system requirements through a number of procedures that include ontology classification, knowledge marking, structure analysis, and security control.

  The re-division of knowledge item sets that have undergone the Ontology normalization procedure is known as Ontology modularization. The most serious issue is the separation principle. In general, the module division should adhere to the following core principles: easier understanding, relative independence, and lower inter-module connectivity. Because of these principles, the system can reuse and share the module because its complexity has been greatly reduced. Modular Ontology is a term that refers to the process of aggregating domain information. The upper services ontology is viewed as the demand, and domain ontology retrieval is viewed as the driving force in the process. Service ontology extracts the keywords and constraints associated with the core business domain ontology, retrieves the collection that meets the demand from the upper services ontology across all atom ontologies, then uses modular ontology languages, such as P-DL, to automate the semantic links and knowledge integration between the atomic ontologies, and finally forms a semantic network constructed by modules.

- **Service ontology** layer. The service ontology layer is a modularization method for services knowledge, with decomposition, expression, retrieval, evaluation, and reconstruction of particular services as its primary functions. Services can be destroyed if the environment changes or if the user's service needs increase. The service destructor process decomposes the current service into a succession of smaller portfolio of services processes, which are

subsequently recomposed as a combination of atomic services ontology by the service interface matching algorithm. The user can either create a new service ontology or use one that currently exists.

This service ontology will be saved in a library to make future use easier. Rather than physical storage, the indexing library describes the core information of service ontology. These services could be dispersed throughout the intranet or the Internet. When users get new or altered services, they can update the service ontology in real time. The system will seek the appropriate service ontology in the service registry library in response to the new specific demand for service from the user, and then develop services by reuse and rehabilitation. Web services are packed into components so that users can call them directly through a single interface.

- **Knowledge service** layer. This layer is made up of several largely independent service modules that have been pre-programmed. The term "service" refers to a type of interface that relates to the purpose of a service module or the data it contains, as well as the limitations. It can facilitate dynamic interaction between services using Service Registry and Enterprise Service Bus in a neutral and standards-based manner.
- **Knowledge users** layer. This layer comprises all the users (both creators and end-users) that are using man-machine interfaces to create, store, call, generate, gather and reuse the knowledge processed, stored and provided by the system via service layer.

To set up the search engine, the following metadata is proposed for analysis:

- Format of the document;
- Name of the document;
- Date of last change;
- Key parts of .docx documents (Head, price, date, description of the project);
- First slide of .pptx files (titles);
- Common phrases, names, words starting with the capital letter;
- Platform name (source of the knowledge, document);

The new framework allows optimizing the process of knowledge structuration and navigation between the elements of knowledge. The incorporation of OCR, KNN and other Machine learning models into Knowledge processing tool block (Fig. 25) simplifies the process of knowledge acquisition and contributes to the user-friendliness of the whole system. In addition, layers of ontology-based services and sub-processes assures that knowledge of all the gathered formats and types would be classified and stored efficiently. Moreover, knowledge graph

implication allows company to visualize the knowledge base as well as connect external applications to interact with it.

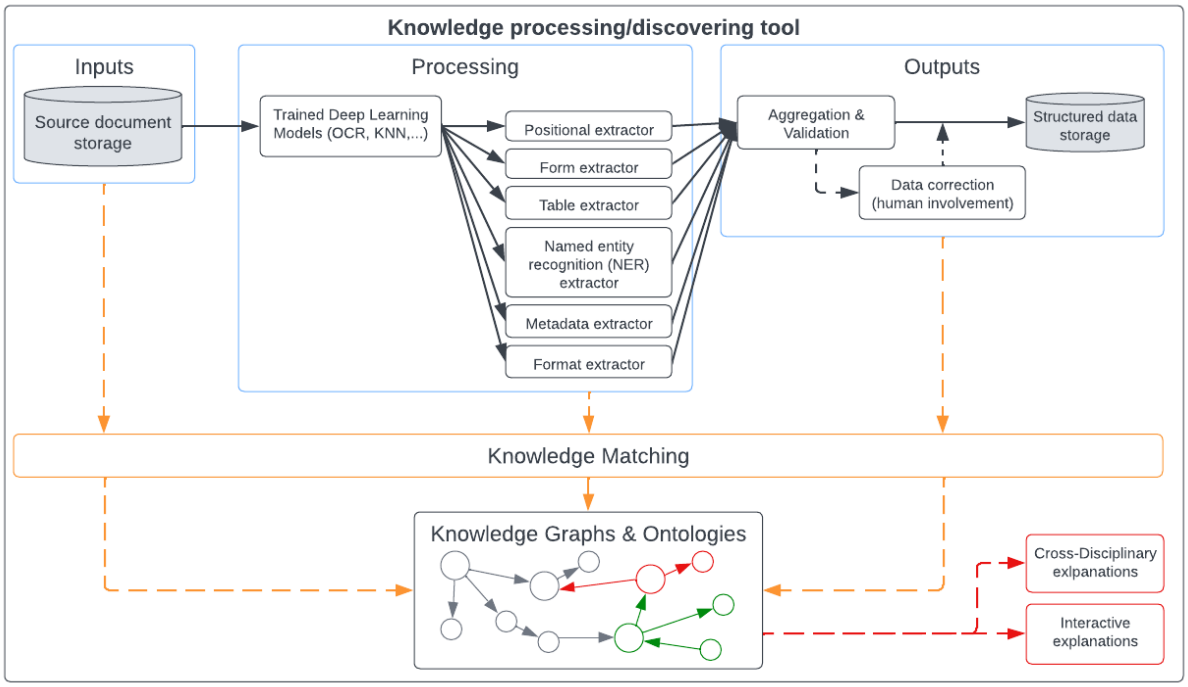

Fig. 25. Detail of knowledge processing tool block of the main framework

In order to demonstrate the workflow within this system, let's proceed with the following example. John is a project manager in the company, and in the process of company transition to digital document management and the proposed KMS, he needs to upload all the files about the projects under his supervision. He opens web-based unified user interface, logs in and in the program uploads the whole folder related to the Project Alpha for the company Org. For better context, this project is the AR/3D visualization of the key opinion leader (KOL) for both desktop and mobile devices.

In this folder, there are the following documents:

- Frame contract (.docx)
- Additional Agreement (.docx)
- 2 Reports (.docx)
- 2 Bills (.docx)
- Initial project Gantt timeline (.xlsx)
- Updated and shortened Gantt timeline from the later period (.xlsx)
- 2 versions of scenario (.xlsx)
- Video with the demonstration of the found bugs (.mp4)

- Script text for KOL (.docx)
- List of changes (.docx)
- Presentation with changes (.pptx)
- Reference pictures (.png)
- Logo pictures (.png)
- Backstage clips of shooting with KOL (.mov)
- Screenshots of several variants of 3D model (.png)
- Several background pictures for Web3D format (.png)
- Screencast videos with customer journey (.mp4)
- Several audios with examples of the background music (.mp3)
- PDF handout files with the QR-code and the instructions (.pdf)
- Presentation with design concept (.pdf)
- UI/UX designs (.pdf)
- Brand fonts and colors (.pdf)
- Company's content reference handouts (.pdf)

John uploads all the files into the Input Heap (knowledge Sources level). Then, for example, system takes additional agreement for the further analysis in Knowledge Processing Tool. With the help of Character recognition as well as Form, Position and NER extractors it finds out what is the domain of this document (AR visualization), official date when it was created, company's name and credentials, project description, decision-making personas as well as the cost structure with total cost. Later, extracted complex data is aggregated and, after John's confirmation that everything is correct, stored in a structured way.

After all the files are processed, there is a great amount of data about the project structure, costs, companies involved, timing etc. This information is then additionally normalized and modularized in the Domain Ontology level and is transferred into the ontology base (with relations and possibility to visualize via knowledge graphs).

Finally, it becomes available to the end users via somatic and semantic search tools, personalized knowledge push, full-text retrieval and other services in the unified user interface with the possibility to search, sort by periods, document types, formats, project and company names and many more tags generated by the system for the overall convenience.

3.3 Future steps

The aforementioned model has a good potential for application in real business. AI can help with the execution of the following tasks: knowledge classification, "things" ordering, generating templates, scheduling, allocation of resources, reporting etc. In terms of areas that can be covered with such AI-KM system, the scope includes:

- Knowledge Management;
- Visual Quality control;
- Production forecasting/planning (with the implementation of decision-making features);
- Energy management (with the implementation of automating equipment);
- Staff assignment;
- Support of CRM-KM symbiosis.

The proposed framework can be applied in the company of mostly any industry due to its universality. Among the preferred spheres there are: IT, education, e-commerce, retailing, manufacturing, production, finance, consulting and even government. Nevertheless, for each company's needs the framework can be adapted. For example, sometimes visualization with KGs may be unnecessary and can be discarded for the cost reduction. In addition, every company has own list of users, both internal and external – and can adapt final web UI for its own needs. The core functionality in this case will stay the same.

Finally yet importantly, in order to achieve sustainable competitive advantage, the following critical success factors (CSFs) should be accomplished: business value addition, adequate security mechanism, enhancement of trust, high-level technical personnel, simplicity of usage, immediate support, supporting legal requirements etc.

Summary of Chapter 3

In conclusion, after the thorough research on basic and modern concepts and frameworks on the spheres of knowledge management, artificial intelligence, with the information gathered from company's research and documentation analysis, the framework for Knowledge management system with the elements of AI have been created. This model can be used to solve the particular case of Way2Win Group as well as can be generalized and adapted to any other company that considers reengineering of its KM processes to achieve sustainable competitive advantage in the era of high-paced and unstable market environment, high level of employees' migration and informational overload.

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