Application of artificial intelligence in content management systems

Dheshan M[1], D Sai Teja[2]
[1,2]SCOPEt, VIT University

Abstract

There are several frameworks to support knowledge management. Some support the knowledge lifecycle, others its production. Currently, the perspective is on knowledge management. Artificial intelligence techniques can help in this management. This work shows how these techniques can be applied in content management systems to improve the knowledge management of these systems.

Keywords: Content Management Systems, Artificial Intelligence, Artificial Intelligence Techniques, Knowledge Management

1. Introduction

The turbulence experienced by contemporary organizations can be identified as the transition to what Drucker [6] identified as “the global society of knowledge”. Globalization has made organizations place themselves in a new competitive position, where the knowledge and behavior of their collaborators have enabled competitive advantages.

Within this context, organizations try to improve their positions in the competitive scenario through the use of knowledge, looking for ways to retain the experience and intellectual resources they have, while trying to apply the new knowledge acquired [7].

In addition to knowledge, the success of an organization depends on many factors [19]:

• The ability of employees and departments to perform the organization's services in the defined time frame;

• Teamwork, through coordination, cooperation and collaboration;

• The degree of innovation, how it is captured, communicated and applied;

• The effectiveness of organizational systems, procedures and policies.

On the other hand, considering that organizations are becoming complex and sometimes multinational, decision-making is becoming very complicated, difficult and risky [10].

In general, there is an acceptance that the knowledge-based economy has grown and that successful organizations in the global knowledge society are those that will be able to identify, value, create and involve their knowledge as assets.

The basis of the knowledge economy is formed by information and communication technology (ICT). It is what allows storing, processing and circulating, quickly and at low cost, an ever-increasing amount of data, being an increasingly important source of productivity gains.

The complexity of organizations raises the question of how to acquire, store, access and reuse knowledge. Faced with this need, Knowledge Management (KM) emerged as a management discipline in the second half of the 1990s.

Before conceptualizing what KM is, the concepts of data, information, knowledge and intelligence need to be discerned. Data are considered as raw facts, while information refers to how a data set is organized [3]. Figure 1 shows the stages of learning evolution.

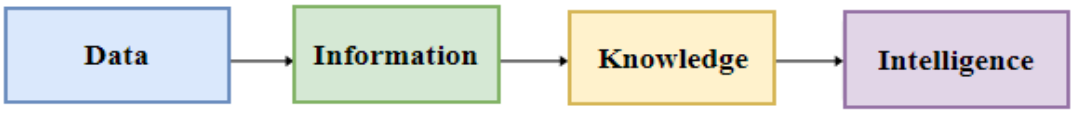

Figure 1: Stages of Learning Evolution [10]

Knowledge can be interpreted as information based on each person's experiences, skills and competences, whereas intelligence is acquired through the transformation of experiences and the acquisition of new knowledge.

For psychology, intelligence is the mental capacity to calculate, reason, perceive relationships and analogies, learn, store and retrieve information, using fluent language, classifying, generalizing and adjusting to new situations. According to Alfred Binet [9], intelligence is the totality of the mental process involved in adapting to the environment.

The GC is a conceptual framework that surrounds all activities of organizations and is required for the intelligent attitudes of these organizations to be on a sustainable basis [19]. KM can also be seen as a discipline that incorporates organizational processes and seeks a synergistic combination of data, information processing capacity of information technologies, creativity and people's ability to innovate [1].

The KM area focuses on exploring and developing knowledge (explicit, documented, tactical and subjective) for organizations to achieve their goals.

Currently, three fields of research in GC can be identified [17]:

• The theory of knowledge, knowledge of organizational culture, measurement of intellectual capital and organizational learning.

• Corporate retention (also known as organizational retention or organizational information systems retention) to improve decision-making.

• Intelligent agents, ontologies and computer-mediated collaboration.

Several authors analyze the role of the "Knowledge Organization" in the knowledge creation process, emphasizing that successful companies are those that create new knowledge, disseminate it throughout the organization and quickly incorporate it as new technologies. and products [7]. This process promotes innovation and the development of competitive advantages [12].

The GC relates to different areas, such as: human resources, marketing and artificial intelligence. In addition, KM covers techniques and processes for creating, collecting, indexing, organizing, distributing, accessing and evaluating organizational knowledge [17].

In general, the main subjects of the CG are the organization, distribution and refinement of knowledge [10].

Knowledge can be generated by data mining tools, it can be acquired from third parties or through content management systems or be refined and updated from a knowledge base. The collected knowledge can be organized through relationships between knowledge elements, integrated into a knowledge base and distributed to be used by decision support applications. As a result, decision support applications are used to refine existing knowledge and display requested knowledge.

Figure 2 shows how knowledge processing occurs:

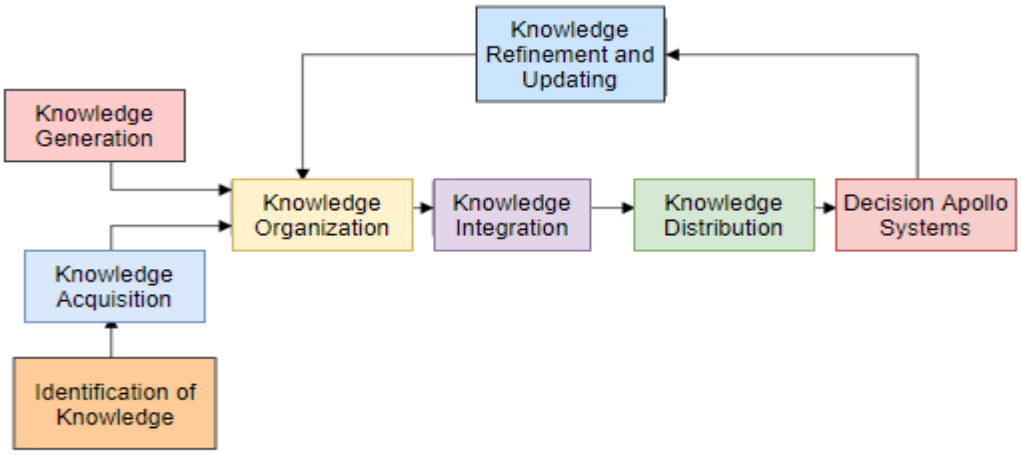

Figure 2: Stages of Knowledge Processing [10]

The presentation of knowledge, that is, how knowledge is shown to members of the organization is an important topic. In general, an organization has different procedures to format its knowledge base. Due to different styles of presentation, members of the organization may have difficulties in reconfiguring, recombining and integrating knowledge from separate or disparate sources.

However, for the KM processes and techniques to be successful, cultural and human aspects must be considered, as well as the development of intelligent systems to improve the performance and execution of tasks involving knowledge.

It is possible to distinguish three phases in knowledge management. In the first phase, corporations have a centralized information repository. The second stage is marked by communities that share knowledge. The third phase concerns the use of wikis, blogs, websites and other resources to expand knowledge management.

Due to the advancement of Web-based technologies and component-based development, several approaches have emerged for the development of artificial intelligence techniques to be used in the context of KM. As an example [17]: user profiles, personalization of human-computer interactions and content management.

The content management systems, in addition to allowing the acquisition of knowledge, can also be used for the distribution of knowledge. Section 2 presents these systems and Section 3 demonstrates artificial intelligence techniques and how they can be used in content management systems.

2. Content Management Systems

The first websites were developed in the first half of the 1990s by university students who wanted to share information with their colleagues. Due to the limited resources of the HTML language, used for the development of the websites, only the essential information was presented [11].

In the second half of the 90s, the proliferation of the number of websites made their management inefficient in organizations. In this period, the role of the webmaster emerged, who had the responsibility of managing the content of the organizations' websites.

The inefficiency in managing the websites was due to the large amount of content that the webmaster had to include in the organization's portal, the technical limitations of the languages used, such as the HTML language, which did not allow separating information from its formatting and the large technological turnover.

Organizations have adopted measures to make the management of their websites efficient. The most important of these measures was the decentralization of website management [11]. The functions, which were the sole responsibility of the webmaster, were divided among several people in the organizations. Content Management Systems (CMS) emerge in this period.

SGC are systems that have been developed to integrate document management systems with information retrieval systems. Since then, there has been a convergence between these two platforms.

Knowledge of the organizational process allows designing a scenario where the SGC enable the creation, storage, manipulation and presentation of information about the organization in a virtual environment.

The growing complexity of many organizational portals, developed using SGC, as well as the complexity of the digital publishing process, made the development of SGC complex.

From the human point of view, the SGC must be understood as a collaborative and distributed work environment, providing support for the accomplishment of tasks that are performed by people. Content management must be defined from the point of view of people's activities and their objectives. For this, a set of processes must be structured for the production of digital publications [2].

The minimum requirements for SGC are: providing applications for creating, editing and storing content, allowing flow control, having an information repository, providing tools for integrating external information and providing models (templates). An architecture with these characteristics can be seen in Figure 3.

To aid in information gathering, CMSs should be flexible and simple to use. Maintaining and updating website content is generally the responsibility of persons with technical skills [11]. However, the SGC must allow any member of an organization to add or change information without technical difficulties.

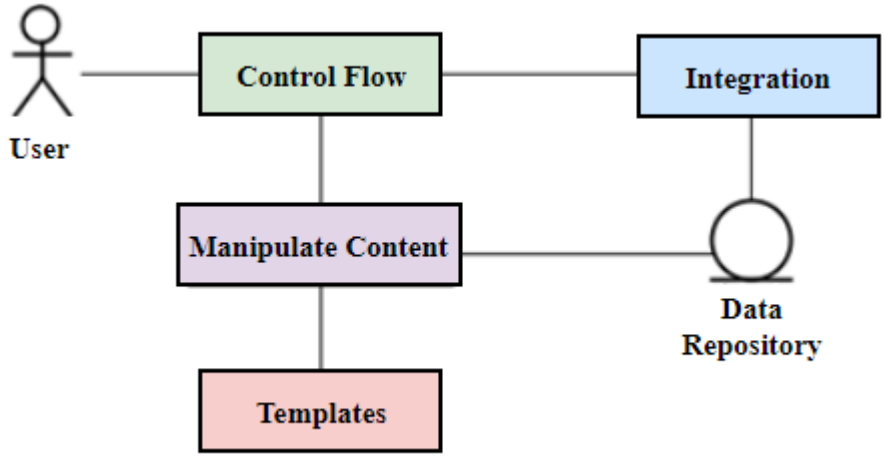

Figure 3: Architecture of a Content Management System

For this, the SGC must provide intuitive interfaces, which must be accessed from a web browser. The requirement of specific programs for the publication of content prevents the portability of the SGC [11]. Thus, the SGC must enable the content producer to publish his information anywhere and at any time.

Correct content management enables any employee of the organization, holder of information, to produce their content on the organization's website. In addition, it reduces publication errors and facilitates the validation process. However, it is important to highlight that the success or failure of a SGC in an organization is not related to the technology, but to the people and the process adopted.

For the definition of a SGC, the simplest process is to use a framework integrated by a set of modules with specific objectives. However, this process becomes complex when the amount of information is large and the nature of this information is different.

SGC vendors need to adapt the necessary functionalities for each organization. In general, there is no universal solution that meets all the requirements of organizations, therefore, it is necessary to choose between the adherence of the functionality to a module provided by the SGC or the development of the requested functionality.

Selecting, implementing and deploying a SGC results in a detailed study and analysis of the organization that will use this system, the organization's objectives, the work processes, the information resources used and the users that the system will affect.

The complexity of information management led to the development of two specific areas: Web Content Management (GCW) and Business Content Management (GCN). GCW uses the Internet environment and its objectives and methods are focused on the production of digital documents and information for the Internet. GCN, on the other hand, are based on the idea of total information management within organizations, through the integration of all the information necessary for the organization to achieve its objectives.

Typical applications of a SGC are editorial websites, communities of practice and corporate portals [11]. Several open source CMS can be found on the Internet ([15] and [16]).

Editorial websites allow a group of individuals to publish information on specific subjects. Vertical information portals, such as newspapers, magazines and blogs, are the most common websites of this nature.

Communities of practice are used by communities that share personal or professional interests. These websites allow people to contribute articles and news. Discussion lists, chats, wikis and forums allow community members to share knowledge.

Corporate portals make it possible to centralize the knowledge of organizations in a single location [11]. Ideas, documents and administrative procedures must be collected in a structured way to guarantee security of access to information.

Typical problems encountered in organizations that the SGC help to solve are
[11]:

• Bottlenecks that hinder the production of content for the Web.

Lack of commitment from users, due to technical difficulties in publication and use.

• Lack of content organization.

• Risks of errors and low quality information.

• Interfaces tightly mixed with content.

In addition to solving typical organizational problems, editorial websites, communities of practice and corporate portals can be transformed with the use of knowledge management systems, making it possible to add value to the information included in these applications.

The knowledge store requires the content manipulation module to create and change knowledge rather than data. Another approach is to take the data and transform it into knowledge based on relationships with other data and system elements.

The main SGC available do not allow the manipulation of knowledge. In this way, the second approach, which seeks to obtain data and transform them into knowledge, becomes more viable. For this, artificial intelligence provides technologies that allow this transformation.

3. AI applied in content management systems

For the application of AI in content management systems, there are two issues that are commonly encountered by AI researchers within the area of knowledge management [17]. The first question is "After decades of research in the area of knowledge engineering, what exactly is knowledge engineering?"

It is possible to understand knowledge engineering and knowledge management as distinct areas of knowledge [17]. Knowledge engineering has, by general agreement, a more technical focus on knowledge (eg representation, organization, reasoning and search). Knowledge management, on the other hand, is more aligned with the objectives of capturing, sharing and reusing knowledge within an organization or between organizations.

Knowledge management projects can continue without any knowledge engineering effort applied to a content management system. However, every knowledge management project involves some knowledge engineering to provide value-added services [17].

The second question about applying AI to content management systems is: There are still no AI systems that can talk to a human. After all, AI should address the toughest problems of content management. The most sophisticated knowledge management tools already accept some form of AI technology, such as Bayesian reasoning, ontologies, data mining and intelligent agents [17].

AI and Knowledge Management (KM) are integrative practices [1]. These solutions are being used by many companies that are beginning to understand how to apply KM practices to add value to their services. Technologies used to support KM initiatives are rapidly being incorporated into KM software. Of particular interest in the use of frameworks is the role of AI in these frameworks.

AI has received attention during the past two decades and has been widely applied in many areas of business. The main categories analyzed are: Expert Systems (ES), Artificial Neural Networks (ANN) and Intelligent Agents (AI) [10].

3.1 Expert Systems

Expert systems emerged as an area of Artificial Intelligence (AI) during the 1970s, from the efforts of researchers to develop computational programs that could reason like humans.

An expert system is a computer program that has a knowledge base about a domain and uses reasoning to perform tasks that human experts could perform [18].

In other words, an expert system is a computational system that has a well-organized body of knowledge that aims to solve real-world problems that involve expert skills in a specific domain. This type of system is capable of presenting conclusions on a given subject in this domain.

For the expert system to achieve its goal, it must interact with the user just as a human expert would, for example, listening to the user, avoiding questions whose answer can be deduced, changing the way of presentation according to the user and taking conclusions, even if the data provided is not completely complete.

Among the characteristics for the interaction of the expert system with the user, the following stand out [13]:

Explain your reasoning. In order to convince the user that the presented solution is suitable for the problem, it is necessary that the system clearly and precisely describe the reasoning used that led to those results.

Acquire new knowledge and modify old knowledge. A human expert is always on the lookout for new information that leads him to modify his knowledge or even complement it. Likewise, an expert system must always keep its knowledge bases up to date.

Maintain ongoing interactions between the human expert and the expert system. Another way is to submit the same raw data used by the human expert and let the expert system learn from it.

The knowledge base is the heart of an expert system and provides the knowledge needed to solve specific problems. Knowledge can be in the form of facts, heuristics (e.g. experiences, opinions, judgments, predictions, algorithms) and it is usually collected from an expert, through knowledge acquisition methods (eg interviews, protocol analysis, questionnaires) [10].

Knowledge acquisition techniques can also be applied to capture knowledge and develop knowledge repositories for content management systems.

The knowledge representation method is another important aspect of an expert system. The language associated with the chosen method must be sufficiently expressive (for example, logical) to allow the representation of knowledge about a domain in a complete and efficient way.

Production Rules is the most common method of representing knowledge. Production systems is a generic name for systems based on production rules, that is, pairs of expressions consisting of a condition and an action. The main advantages of production systems as a knowledge representation method are: modularity, uniformity and naturalness. As disadvantages it is considered: inefficiency in execution time and complexity of the flow of control to solve problems.

Another common feature of expert systems is the existence of an uncertain reasoning mechanism that allows representing uncertainty regarding domain knowledge. Due to the need to express uncertain knowledge, several methods of knowledge representation have been developed:

Logic: basis for most knowledge representation formalisms, either explicitly, as in expert systems based on the Prolog language, or masked in the form of specific representations that can easily be interpreted as logical propositions or predicates.

Semantic networks: consists of a set of nodes connected by a set of arcs. The nodes, in general, represent objects and the arcs, binary relations between these objects. However, the nodes can also be used to represent predicates, classes, words of a language, among other possible interpretations, depending on the adopted semantic network system.

Frames or frames: allow the expression of the internal structures of objects, maintaining the possibility of representing inheritance of properties as in semantic networks.

Content Management Systems can take advantage of these techniques and apply them to support knowledge codification.

Figure 4 presents an architecture of an expert system. According to Figure 4, an expert system presents an architecture with the knowledge acquisition and explanation subsystems and the modules: knowledge base, inference engine, working memory and user interface.

The knowledge base gathers the expert's knowledge modeled according to the defined knowledge representation method. The inference engine examines the content of the knowledge base and defines the order in which inferences are made. In this way, according to a user query, the inference engine transfers facts and rules to working memory, which stores the most recent facts and rules.

The knowledge acquisition subsystem is responsible for updating the knowledge base, through interaction with the expert, the knowledge engineer and the explanation module. The explanation subsystem is responsible for describing the reasoning of the system to the user, that is, it details the reasoning used by the system to obtain the result (solution).

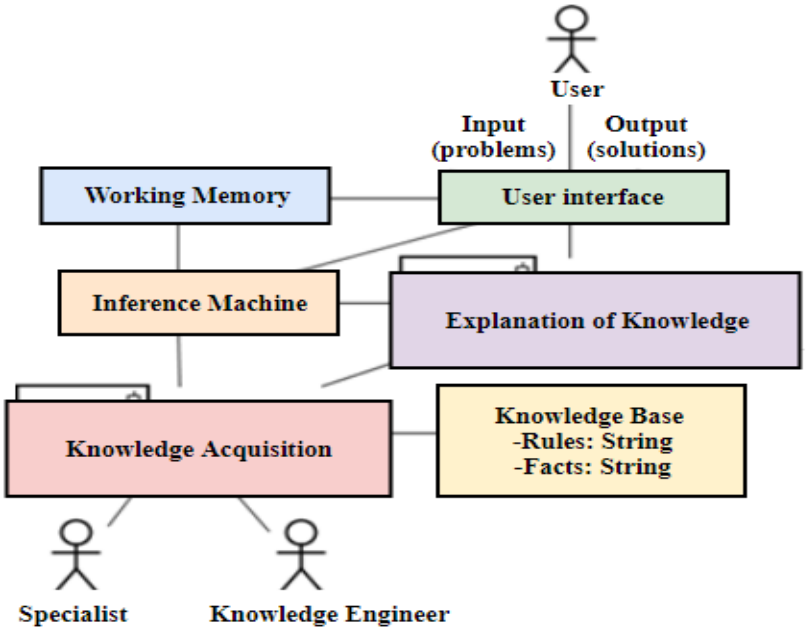

Figure 4: Architecture of an expert system. Adapted from [7]

Among the benefits of using expert systems, it can be highlighted [8]:

• Helps reduce human error and speed up tasks;

• Increases performance and quality in problem solving;

• Presents stability and flexibility;

• Combines and preserves the knowledge of specialists;

• Contemplates multiple hypotheses simultaneously;

• Integrates several tools;

• Shows greater efficiency and optimization of results;

• Is not affected by psychological issues, stress and external factors;

• Has greater speed in solving problems;

• Can solve problems as well as a human expert.

3.2 Artificial Neural Networks

Artificial Neural Networks (ANN) were originally developed in the 1940s by neurophysiologist Warren McCulloch, from MIT, and mathematician Walter Pitts, from the University of Illinois. They were the first researchers to treat the brain as a "computational organism" [5].

ANNs consist of a method for solving AI problems, based on the development of systems that simulate the human brain, including its behavior, that is, learning, making mistakes and making discoveries.

The ANN approach is seen as completely different from expert systems (Section 3.1), as in this approach there is no explicit knowledge base, but a set of derived relationships between data. Thus, it cannot be said that artificial neural networks have knowledge about a specific domain [10].

ANNs are composed of a large number of artificial neurons that are interconnected in a network to solve problems. The technique for solving problems is similar to that used by humans.

The artificial neuron is a logical-mathematical structure analogous to a processing unit that accepts and combines stimuli from several other artificial neurons and seeks to simulate the shape, behavior and functions of the biological neuron.

Figure 5 shows a basic model of a neuron j with input xk, synaptic weights wj, activation level J and output f (J).

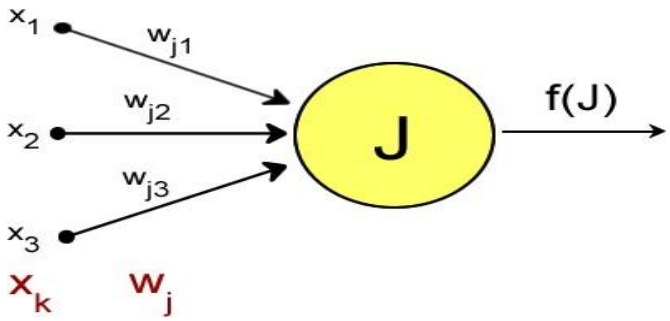

Figure 5: Basic model of a neuron

As shown in Figure 5, each neuron j has an input data vector $X_k = [X_1, X_2, \dots X_n]^T$, an internal activation J, an activation function f (J) and the synaptic weights $W_j = W_{j1}, W_{j2}, \dots, W_{jd}]^T$, which connect the elements of X_K to neuron j.

Learning of neural networks occurs when there are significant changes in synapses

between neurons. A synapse is the name given to the connection between neurons. These connections are assigned values, called synaptic weights, which are used to store knowledge.

To determine whether a change is significant, the activation of neurons is checked. If certain connections are used the most, then those connections are strengthened while the others are weakened.

There are basically 4 types of learning in artificial neural networks:

Supervised: sets of input patterns and their corresponding output patterns are successively presented to the network. The network adjusts the weights of the connections between the processing elements ('neuron'), until the error between the output patterns generated by the network reaches a previously defined minimum value;

Reinforcement: instead of providing the correct outputs to the network regarding individual training, the network receives a value that says whether the output is correct or not;

Unsupervised: the network analyzes the input data sets, determines some properties of the data set and learns to reflect these properties in its output;

Hybrid: The neural network layers can use supervised or unsupervised learning.

When an artificial neural network is implemented for a given application, a period is required for this network to be trained. As with biological systems, learning involves tweaking the connections that exist between neurons. In other words, the “learned” information is stored in the form of numerical values, called weights, which are assigned to connections between processing neurons in the network [10].

With a structured neural network, a series of values can be applied to a neuron, which is connected to other neurons by the network. These values are multiplied in the neuron by the weight value of its synapse. Then these values are added together. If this sum exceeds an established limit value, a signal is propagated by the output (axon) of this neuron. Then, this same step is performed with the other neurons in the network. That is, the neurons will face some kind of activation, depending on the inputs and synaptic weights.

ANNs can be categorized by their topology, that is, by the number of layers, processing elements and connections; by the characteristics of its processing elements; and by the learning laws to which they were submitted [5].

Figure 6 presents an architecture of a neural network with 3 layers.

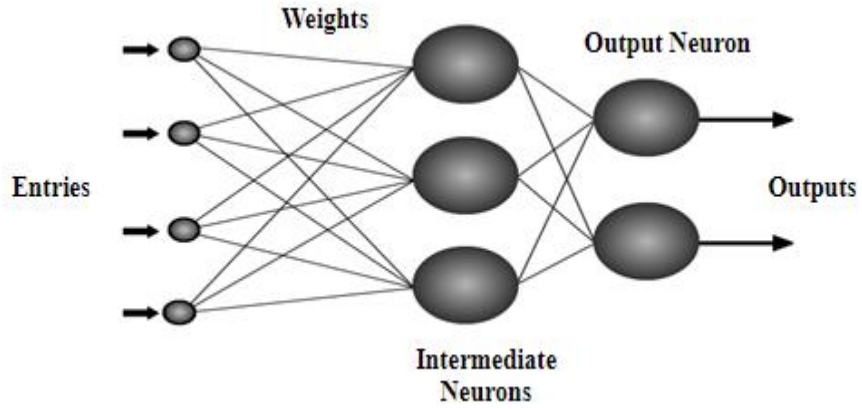

Figure 6: Neural Network with 3 layers

The main advantage of this technology is that it can operate with incomplete data to generate and demonstrate apparent intuition [10]. In addition, with ANNs it is possible to work analogously with the brain, which should be enhanced within a framework of knowledge management. It is also possible to create user profiles to allow information to be forwarded to specific individuals according to their preferences and interests.

Content management systems can take advantage of this technology in distributing and sharing knowledge. Rather than simply having a passive distribution mode, where the organization's knowledge repository is provided for individuals to access it, a specific module can be changed for analysis and knowledge distribution to stakeholders [10].

On the other hand, a disadvantage of ANN technology is the fact that they require inputs to be presented in various ways, so they can be subject to weighting of learning algorithms [10]. Unlike expert systems, which also accept input symbols, this is not in keeping with the domain of knowledge management, which assumes a world based on entities and practical understanding.

3.3 Intelligent Agents

Artificial Intelligence (AI) has 3 distinct approaches, the symbolic, connectionist and distributed approach. Distributed Artificial Intelligence (DIA) originates in sociology, uses intelligence models based on social behavior and seeks to solve problems cooperatively in a certain environment through distributed agents.

To understand Intelligent Agents (AI), it is first necessary to understand what an agent is. An agent is anything that can perceive the environment and act on it [14].

An intelligent agent is a computational system located in some environment and that is able to perform autonomous actions in this environment must be sensitive to the environment, respond to changes that occur in this environment, have goal-oriented actions, take initiative and interact with other agents to solve problems or help solve problems for other agents.

In general, agents are endowed with a large amount of knowledge, professional experiences and beliefs that they use to carry out their tasks. The study of intelligent agents has become one of the most important fields in distributed artificial intelligence [10].

Multi-agent systems are systems that use multiple agents to perform their tasks. These systems can be reactive or cognitive. Reactive agents do not store their actions, do not represent the environment, do not explicitly represent knowledge and act according to the instantaneous situation. Figure 7 shows the architecture of a simple reactive agent.

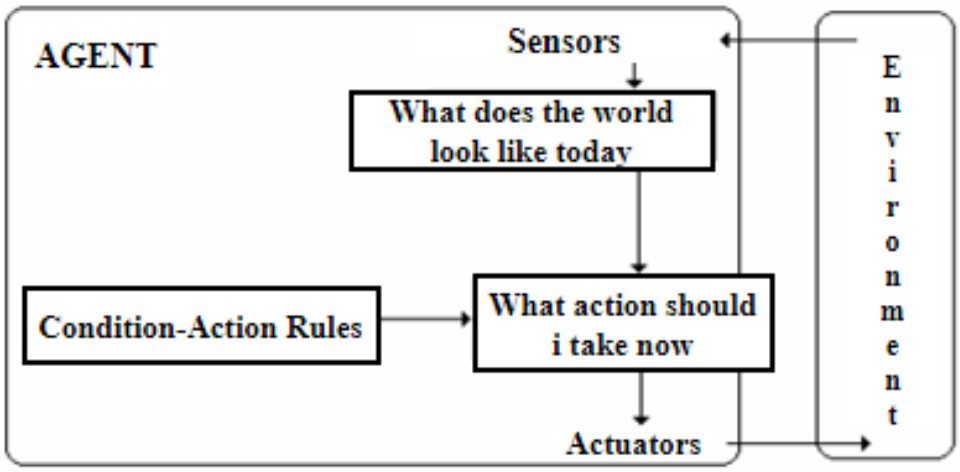

Figure 7: Simple Reactive Agent

Simple reactive agents have sensors and actuators that observe the environment. When the agent observes something relevant through the sensors, it checks the current appearance of the world and performs actions in this environment through the actuators. Actions are oriented according to Stimulus -Response (Action-Reaction). Cognitive agents have an explicit representation of knowledge about the environment and other agents that collaborate with it and can store their actions.

In addition to simple reactive agents and cognitive agents, agents can be model-based, goal-based, utility-based, or learning-based. More details about these agents can be found in [14].

Intelligent agents differ from objects (from the object-oriented paradigm) in several points. Intelligent agents manipulate objects to perform their tasks (an intelligent agent can be seen as an object with a head). The behavior of an intelligent agent (the tasks they perform and how the tasks are performed) can be dynamically modified, due to learning or the influence of other agents. Intelligent agents can be autonomous, can perform actions independently and can be mobile. They can search dynamically to help solve problems [10].

The search and retrieval of knowledge methods in content management systems can be aided by intelligent agents. In addition, they can be used to assist in combining knowledge to create new knowledge.

From the relationship of knowledge, intelligent agents can create multiple perspectives of the same situation. These perspectives can contribute to increase the number of possible solutions and improve the quality of the decision-making process [4]. Furthermore, intelligent agents can be applied to analyze knowledge and disseminate certain pieces of information and knowledge (eg summaries, recommendations) to those who could make use of these pieces.

4. Conclusions

Artificial intelligence techniques can be used in content management systems to improve the knowledge management of these systems. However, there is no ideal technique to be adopted.

The content handling module of a content management system with community of practice characteristics can be improved with the use of specialist systems. The improvement consists of allowing the manipulation of the knowledge of specialists due to the nature of communities of practice.

The template module of a content management system can be adapted to display interfaces according to the user profile using neural networks.

Intelligent agents make it possible to transform data from content management systems into knowledge. In addition, intelligent agents are very flexible and can be used in the main modules of content management systems.

Finally, choosing the technique to be adopted depends on the type of content management system adopted and the objectives of the organization.

The main advantage of organizations in applying AI techniques in their current content management systems is to add value to their intellectual capital. For the new economy, this means competitive advantage.

References

[1] Alvarado, M; Sheremetov, L; Bañares-Alcántara, R; Cantu-Ortiz, F. Current Challenges and Trends in Intelligent Computing and Knowledge Management in Industry. Knowledge and Information Systems, 12(2):117–127, 2007.

[2] Boiko, B. Content Management Bible. John Wiley & Sons, Inc. New York, NY, USA, 2001.

[3] Bollinger, A; Smith, R. Managing Organizational Knowledge as a Strategic Asset. Journal of Knowledge Management, 5(1):8–18, 2001.

[4] Carneiro, A. The Role of Intelligent Resources in Knowledge Management. Journal of Knowledge Management, 5(4):358–367, 2001.

[5] De Medeiros, J. Geographical Databases and Artificial Neural Networks: Technologies to Support Territory Management. PhD thesis, 1999.

[6] Drucker, P. Post-Capitalist Society. Butterworth-Heinemann Oxford, 1993.

[7] Fowler, A. The Role of AI-based Technology in Support of the Knowledge Management Value Activity Cycle. Journal of strategic information systems, 9(2-3):107–128, 2000.

[8] Giarratano, J; riley, G. Expert Systems: Principles and Programming. PWS Publishing Co. Boston, MA, USA, 1994.

[9] Lagasse, P; others. The Columbia Encyclopedia. Gale Group, 2000.

[10] Metaxiotis, K; Ergazakis, K; samouilidis, E; Psarras, J. Decision Support Through Knowledge Management: The Role of The Artificial Intelligence. International Journal of Computer Applications in Technology, 19(2):101–106, 2004.

[11] Parreiras, F; bax, M. Generation of Content Management Systems with Free Software. Perspectives in Information Science, 10(2), 2005.

[12] Prahalad, C; Hamel, G. The Core Competence of Corporation. Springer, 1990.

[13] Rich, E; knight, K. Artificial intelligence. McGraw-Hill, 1994.

[14] Russell, S; Norvig, P. Artificial Intelligence: A Modern Approach. Prentice Hall, Inc. Upper Saddle River, NJ, USA, 1995.

[15] The CMS matrix. The CMS Matrix Home Page. http://www.cmsmatrix. org/, last accessed in November 2007.

[16] The Open Source Collective, INC.. Opensource CMS Home Page. http: //www.opensourcecms.com/, last accessed in November 2007.

[17] TSUI, E; Garner, B; Staab, S. The Role of Artificial Intelligence in Knowledge Management. Knowledge-Based Systems, 13(5):235–239, 2000.

[18] WELBANK, M. A Review of Knowledge Acquisition Techniques for Expert Systems. Martlesham Consultancy Services, British Telecom Research Laboratories, 1983.

[19] WIIG, K. Knowledge Management Foundations: Thinking about Thinking-how People and Organizations Represent, Create, and Use Knowledge. Schema Press, Limited, 1994.

[20] Wooldridge, M; Jennings, N. Intelligent Agents: Theory and Practice. Knowledge Engineering Review, 10(2):115–152, 1995.