اعتماد شبكات التعلم العميق لتطوير إدارة المعرفة واتخاذ القرار في قطاع الأعمال

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الملخص

تهدف هذه الورقة لدراسة تأثير تقنيات الذكاء الاصطناعي كالشبكات العصبية العميقة في إدارة المعرفة في شركات الأعمال. يساعد الذكاء الاصطناعي على تسهيل الحياة اليومية ومتطلباتها على الأفراد عامةً ويلعب اليوم دورًا رئيسيًا في نمو قطاع التجارة خاصةً. ويعتبر استخدام إدارة المعرفة في المنظمات أحد أكثر المجالات ملاءمة لتطبيق تقنيات الذكاء الاصطناعي لما له من تأثيرٍ رئيسيٍ على تحسين الأداء العام. تحتاج منظمة الأعمال إلى نظام ذكي لإدارة المعرفة المتزايدة بشكل فعّال بمرور الوقت؛ بينما يعد التعلم العميق أحد أكثر تقنيات الذكاء الاصطناعي قدرة على معالجة المعرفة المتزايدة. في هذه الورقة، استعرض الباحث مقدمة موجزة عن الشبكات العصبية الاصطناعية والتعلم العميق، وناقش أهمية الذكاء الاصطناعي ودور التعلم العميق في إدارة المعرفة في منظمات الأعمال. وعليه قدم توصياته باتباع مجموعة من الإجراءات المتسلسلة لتطوير نظام أعمال ذكي يستخدم التعلم العميق.

الكلمات المفتاحية

إدارة المعرفة؛ الشبكات العصبية؛ التعلم الآلي؛ التعلم العميق؛ تصنيف الأنماط.

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Adopting Deep Learning Networks to Enhance Knowledge Management and Decision-Making in Business Industry

Abstract
The aim of this paper is to study the impact of applying Artificial Intelligence (AI) techniques, particularly Deep Neural Networks, on Knowledge Management (KM) in business enterprises. AI facilitates easier and faster management of various aspects of life. Today, AI plays a key role in the growth of the commercial industry. KM in organizations is one of the most suitable areas for applying AI techniques due to its significant impact on improving overall organizational performance. Business organizations need an intelligent system to effectively and efficiently manage their growing knowledge over time, and Deep Learning (DL) is one of the AI techniques that can process vast amounts of knowledge. This paper provides a brief introduction to Artificial Neural Networks (ANN) and DL, discusses the importance of AI in business, and explains how DL manages knowledge in enterprises. Based on these discussions, recommendations and sequential procedures for developing a DL-supported intelligent business system are proposed.

Keywords
Knowledge Management; Neural Networks; Machine Learning; Deep Learning; Pattern Classification.

Section One: Introduction

In recent decades, technology has grown rapidly. All over the world, the significant role in most fields is playedby Information Technology (IT). New technologies have appeared and are being used widely in the era of information. Many of them are applied to increase Business Intelligence, such as Artificial Neural Network (ANN) and Deep Learning (DL) (Dastres & Soori, 2021).

AI (Artificial Intelligence) is one of the most impacting branches in IT today. AI is a computer science field that provides systems the ability to act and think as experts. Philip and Jackson (1985, 70) defined AI as:"A branch of computer science in which machines perform tasks similar to those of the human mind such as learning or reasoning". Applying AI in organizations leads to reducing cost, enhancing services, making best decisions etc. According to Gartner (Rowsell-Jones & Howard, 2019), the use of AI among organizations tripled in the past year, rising from (25%) in 2018 to (37%) in 2019, and a (270%) increase in the Past Five Years.

On the other side, KM (Knowledge Management)is one of the important fields that are increasingly supported by AI according to the fact that most organizations nowadays are knowledge-based Systems, and managed by business intelligent system.KM helps organizations achieve goals and choose best strategies for different situations with many benefits, such as enhancing productivity, minimizing faults, creating competitive advantages in market, and providing faster and smarter decisions (Sokoh & Okolie, 2021).

All of these can be achieved better by increasing the advantage of using AI techniques in managing knowledge to provide more accurate knowledge, in a faster way and at a lower cost. AI also helps us find the best knowledge when we need it.

Applying AI techniques in KM will provide the ability to reason, analyze situations, cluster business cases, discover tacit knowledge, create new knowledge, share this knowledge between employees rapidly, and respond to their environment in real time. AI techniques help organizations to efficiently and effectively manage their employees. For that reason, organizations employ AI to improve KM processes and enhance overall organizational performance (Jarrahi et al., 2022).

Personal intelligent assistants, a new type of AI system, have the potential to play a unique role in personal knowledge management. One of the most significant issues of the digital environment for knowledge workers is information overload (Pauleen & Gorman, 2016, 23).

ANNs are one of the most important subfields under the shade of AI. They were originally developed similar to the biological neural network and it is generally used to find patterns within data, which makes the process of dealing with knowledge (creating new knowledge, discovering tacit knowledge, sharing knowledge between employees themselves or with clients, and applying knowledge) easier and more effective in organizations (Van Gerven & Bohte, 2017).

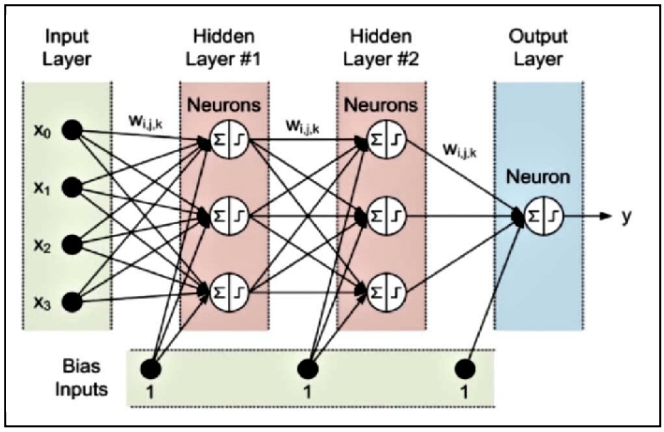
ANN is "a calculation method that builds several processing units based on interconnected connections. The network consists of an arbitrary number of cells or nodes or units or neurons that connect the input set to the output. It is a part of a computer system that mimics how the human brain analyzes and processes data" (Dastres & Soori, 2021).

Machine Learning (ML) is an application of AI based on the idea that we have really to be able to give machines access to data and let them learn for themselves. ML uses ANNs for modeling and processing data (Janiesch et al., 2021).
DL is a subset of ML. It has a significant impact in wide areas and several applications such as Virtual Assistants, Digital Marketing, Entertainment, Visual Recognition, Healthcare, Self-Driving Cars, etc. (Kenneth, 2019).
A survey by MIT Technology in 2017 of (375) qualified respondents from different industries including business and financial services shows that (60%) of respondents had already implemented Machine Learning techniques -among them DL- in their companies and decided to continuously invest in ML (MIT, 2017). DL proved to be a very suitable technique to enhance KM, and this is the core that this research aims to show.
The rest of this research is divided as follows: section 2 introduces ANNs and DL. Section 3 presents literature reviews that discussed the impact of applying ANNs and DL on organizations. Section 4 discusses applying AI to business industries and its impacts on KM and shows DL algorithms' methods. Section 5 presents advises and proposed steps to build an intelligent business system supported by DL. Finally, the conclusions are presented in section 6.

Section Two: Artificial Neural Networks & Deep Learning

"Artificial Neural Network or ANN is an information processing paradigm that is inspired by the way the biological nervous system such as the brain processes information. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve a specific problem." (Akkaladevi et al., 2009).
ANN contains a large number of units often called neurons arranged in many layers: input layer, hidden layers, and output layer. A neuron in the input layer receives input from other neurons or from an external source which the network will learn from. A weight is assigned to the input according to its importance; this weight indicates the strength of that input. Neurons in a hidden layers will transform inputs into something that the output neurons can use. Then, neurons in output layer will compute an output by applying a function to the weighted sum of its inputs (Andres, 2019).

Figure 1. ANN structure example (Andres, 2019).



As shown in Figure 1, x0, x1, x2, x3 represent inputs in the input layer on the network. Each one of them is multiplied by a weight. The weights are represented as $W_{i,j,k}$ to assign the importance a neuron has for the next layer. A function is applied in the first layer to calculate the weighted sum of the inputs: $y_j=\sum(x_i*W_{i,j,k})+b_j$, this could then be used for the next neurons' layer, and so on to reach the final output Y. These computations give the system the ability to learn and make decisions based on inputs without depending on users (Andres, 2019).

Applying ANN in different systems has proved that using these techniques - while focusing on performing specific tasks - will achieve better results. This advantage can be supported by using DL, where systems learn by examples. As this network uses the structure of neural network, it is also called a deep neural network (Janiesch et al., 2021).

A simple ANN contains (2) to (3) hidden layers, while Deep Neural Networks may contain over (150) hidden layers. Moreover, unlike simple ANNs, they often contain advanced neurons. That is, instead of a simple activation function, they may involve complicated tasks or several activations in one neuron (Janiesch et al., 2021). These facts explain what the term "Deep" refers to. DL enables systems to manage their work in the absence of humans, and can now do work that could not been done before without experts. As mentioned above in the introduction section, the self-driven car is one of DL applications' examples, where the car can distinguish a lamppost or a pedestrian, and know when to go on or stop. More accurate results are needed from a complex network with a huge amount of data, which means more hidden layers to be structured in that network.

DL is considered one of the most significant developments of computer science in general and AI in particular. These days, it has a key impact in nearly all scientific fields, and can transform businesses as never before.

Section Three: Literature Review

A study by Kraus et al. (2020) provided a mathematical overview of Deep Neural Networks; they proposed a deep-embedded architecture tailored to operations research use cases and derived guidelines and implications for researchers in operations research who want to enhance their capabilities in DL business analytics. Three case studies are studied to show the impact of DL in business systems' prediction, these are: Load forecasting of IT service requests, Sales forecasting, and Insurance credit scoring. These case studies are selected from different areas to ensure that deep neural networks help in improving the overall performance of operations. Their proposed deep-embedded network attains performance improvements between (1.56%) and (21.73%) across all metrics over a default, out-of-the-box architecture.

Another research by Kratzwald et al. (2018) demonstrated that increasing performance based on using DL requires customization of recurrent neural networks with regard to bidirectional processing, dropout layers as a means of regularization, and weighted loss functions. It proposed sent2affect, which is a tailored form of affective computing transfer learning, and found that both recurrent neural networks and transfer learning outperform traditional machine learning.

In (Fischer & Krauss, 2018), the researchers provided the Application of long short-term memory networks to financial market predictions. As they showed, these networks exhibit the highest returns and highest predictional accuracy. They deployed long short-term memory networks based on DL to predict out-of-sample directional movements for the constituent stocks of the S&P 500 from 1992 until 2015. The daily returns were about (0.46%) and a Sharpe ratio of about (5.8) prior to transaction costs. They concluded that long short-term memory networks based on DL better than memory-free classification methods such as random forest (RAF).

In 2017, researchers at Microsoft Corporation and the University of California Santa Cruz proposed in (Zhu, 2017) a new model to enhance Deep Neural Networks by using forest-based models. Tree or forest-based models provide low serving costs, so they are widely used, but significantly rely on carefully engineered features. To reduce this cost, they proposed a Deep Embedding Forest Model that has the advantages of both forest-based models and DL. They also proposed a joint optimization algorithm called partial fuzzification, and after comparing with it they concluded that the two-step Deep Embedding Forest has achieved near optimal performance. Experiments based on large scale data sets from a major sponsored search engine proved the proposed model's efficacy.

Chen and Lin (2014) described a Modified Neural Networks such as Deep Belief Network (DBN) that use labeled and unlabeled data with supervised and unsupervised learning respectively to improve performance.

Section Four: Using AI and DL Algorithms in Business

Old traditional systems might take months to achieve goals, but modern AI-based systems can do it in as little as a few days. In this section, the importance of AI and DL techniques in business enterprises is explained, and the different types of DL algorithms' methods illustrated.

4.1 Impact of AI on KM Processes

Knowledge Management, Analytics, and data processing, all these concepts have the most significant impact on overall business organizational performance today. Traditional automated systems are not designed to handle the exponential growth in organizations in terms of sources and data complexity.

In recent days, business enterprises need real-time analytics that can help managers to make effective and fast decisions according to the rapid changes in markets' environments, helping them to stay competitive in their industry.

It is important for enterprises to have powerful systems with the following capabilities: providing speed data access, retrieving knowledge from multiple sources, sharing knowledge at low cost and high speed between employees, and analyzing huge amounts of data using intelligent algorithms such as deep learning algorithms-as it is recommended by this research -, providing correct results and accurate decisions when it's needed with easy-to-use interface.

It is worth noting that talking about providing two processes of KM - which are capturing knowledge and sharing knowledge- had been facilitated by many different digital technologies such as access to cloud storage and internet services, and by using portable devices such as PDA and mobile phones. Employees can get knowledge out of their brains and share it with others via plenty of tools, but this leads to a new problem which is the difficulty of discovering knowledge and rearranging it to create new knowledge. AI techniques provide the solution by using modern technologies to simplify knowledge discovery.

Systems will learn how to predict knowledge -knowledge discovery-that employees look for based on their behaviors and the kind of knowledge they have used before or other employees searched for in the past by using DL algorithms (Bajaj et al., 2020). Cloud drives that are programmed and managed with AI techniques help in providing employees the ability to access needed knowledge regardless of where they are. It can determine the accurate required knowledge for employees according (Bajaj et al., 2020).

The process of discovering tacit knowledge or new emerging knowledge can be achieved by pattern classification algorithms to recognize patterns and different groups of data, and process these patterns to extract knowledge intelligibly (Patalas-Maliszewska & Śliwa, 2019).

For example, discovering knowledge about customer's market demands to improve providing preferable products can be done by supplying the network with the feedback obtained by monitoring customers' behavior such as number and kinds of complains, details of purchases, prices of most-selling products and so on; this will lead to discover knowledge about customers' demands.

Knowledge discovery can be made by exploring large amounts of data to create patterns that can be presented as knowledge. The extracted knowledge will be reused with source data in data sets, to produce new patterns that will be added to the knowledge base. The process of business patterns discovery is a very important issue in business industry. Identifying those patterns has a significant impact in developing services, brands, and products. More accurate results achieved by applying pattern classification in the system, will lead to make better decisions (Patalas-Maliszewska & Śliwa, 2019).

DL algorithms proved that they are very efficient in pattern classification based on many factors such as dealing with a huge amount of input data, having the ability to learn by itself by monitoring the employee's/customer's behavior, clustering knowledge to different types of clusters or groups, by applying mathematical computations multiple times in many hidden layers forward and backward (Janiesch et al., 2021). DL algorithms can also recognize new patterns, by identifying current patterns and combining them with different patterns or other recently obtained patterns. This innovation and creativity achieved by matching and combining ideas will provide interesting and amazing results which are not expected before. The chance of innovation will increase as hidden layers increased in deep neural networks (Janiesch et al., 2021).
DL algorithms can produce a wide range of new knowledge and examine them with no need for human efforts, according to the fact that DL algorithms let machines learn for themselves. DL algorithms' performance exceeds human performance. As a result, it will increase the effectiveness and efficiency of organizations - the key and significant factors to sustain organization's market value-.
Pattern Classification as a solution to difficulties in knowledge discovery will eliminate the laborious process of this process. It is proposed to use one of the supervised DL techniques; this technique assigns patterns in training sets (previous stored examples) to extract decisions, which is "Categorization" (Djellali & Adda, 2017).

4.2 Types of DL Algorithms' Methods

In DL, machines learn by studying the input data. Different kinds of algorithms can be applied in Deep Neural Network to detect patterns and make complex computations to support and provide decisions. In (Kumar& Sarkar, 2017), a research paper was presented where the researchers provided a case study on various classification algorithms of ML and DL.

4.2.1 Supervised Learning

In Supervised Learning algorithms labeled data sets are already inserted into the network and some of them are assigned to make the right decisions. Expected output variables are already inserted too. This type of algorithm needs supervisors to provide experience to help in optimizing performance criteria. They are also called error back-propagation algorithms, because of the way it is used to find error signals and correct them, by comparing and matching the output calculated and the expected output to adjust the weights of neurons that are proportional to the product of the error signal. Error back propagation can be performed in two ways: Forward Pass, and Backward Pass. Systems use Supervised Learning will learn explicitly and direct feedback is given. In Supervised Learning machines are taught by examples (training sets). Supervised Learning algorithms used with lots of variables with much information and previous knowledge stored about these variables (Nevala, 2017; Sathya & Abraham, 2013).
For example, supervised algorithms used to expect a price of a house in a big city based on its area, location, number of floors, and age of construction, and other variables.

4.2.2 Unsupervised Learning

In Unsupervised Learning algorithms, unlabeled data sets are inserted into the network. Output variables will not be given. These algorithms discover new information and patterns without the need of a supervisor. Unsupervised Learning is computationally complex compared with Supervised Learning; it can find all kinds of unknown patterns in data, but it is preferred in systems, according to the fact that obtaining unlabeled data from a computer is easier than labeled data. While the training data sets have no specific expected outputs, the algorithm attempts to find similarities in patterns by extracting and analyzing them (Nevala, 2017; Sathya&Abraham, 2013).

Unsupervised DL algorithms have the advantage of self-learning of patterns which helps in providing answers to any unexpected behavior of customers or changes in the market, even with unlabeled data sets. Unsupervised algorithms can increase innovation and provide amazing ideas in business enterprises.

4.2.3Semi-Supervised Learning

In Semi-Supervised Learning algorithms, a mixture of labeled and unlabeled data sets is inserted into the network. The system must learn the structures to organize the data. The algorithm can benefit from labeled data sets and improve the accuracy of outputs compared to a fully unsupervised algorithm where no labeled data sets can be obtained. Such these kinds of algorithms are used in classification and regression (Nevala, 2017).

4.2.4Reinforcement Learning

In Reinforcement Learning, the algorithm attempts to find the best way to reach the decision, or to enhance performance on a particular task. It learns from each step it executes. It depends on past feedback from previous actions and from new explorations to expect the best next action. More iterations of feedback lead to find better choices. Such these kinds of algorithms are useful for training robots (Nevala, 2017; Sathya & Abraham, 2013).

The best DL algorithm method to be used in business enterprises' systems depends on many factors related to the inputs and outputs of the system, such as amount of data, kind of data set (labeled or unlabeled), accuracy in previous knowledge, availability of expected outputs, forward or backward Propagation, etc. Choosing the suitable DL algorithm depends on the value of cross- validation (R^2) for the majority of the system's dataset.

Many factors must be determined before designing the network: (a) a number of hidden layers, (b) the number of neurons in each layer, (c) the method for acquiring best weight for neurons. And then, the Deep Neural Network will be implemented and run, to trial and train.

Section Five: Building Intelligent Business System Supported with DL

All stakeholders aspire to have an intelligent business system, to help in improving overall performance, saving time, providing accurate decisions, minimizing efforts of experts and employees, and managing knowledge in efficient and effective way.

How can an enterprise build this intelligent system? In this section, some advices are introduced to be considered before establishing the new system. In addition, Sequential steps to build the system are proposed to facilitate the process.

5.1 Applying DL Algorithms in Business Enterprises Systems

Applying DL algorithms in business enterprise systems continues to grow nowadays as a result of stakeholders' acceptance and trust in modern technologies and the impacts of these technologies on enhancing organizational performance, and the facilities and services are provided by many marketing solutions for using information technology infrastructures.

Establishing business systems supported with DL mechanisms requires the contribution of all employees as it takes effort and time. Stakeholders and shareholders have to be involved and provide support to users (employees and clients). If enterprises fail to provide IT techniques, they will not succeed in applying AI and DL algorithms in their systems.

Some advices are provided below to help enterprises how to begin to build an intelligent system with DL capabilities.

-Establish an appropriate infrastructure to support communications and networks.

-Contract with experts in the fields of AI and business industry to gain benefits of their experiences and add them to the knowledge base.

-Encourage employees to use modern technologies and helping them to accept it.

-Provide periodic maintenance to the system and ensure it is up to date with modern technologies in the AI field.

-Provide cloud services via any cloud solutions providers to facilitate the use of common intelligent applications for all employees in one environment.

-Engage Business employees and end-users in Validation.

5.2 Steps of Building Deep Neural Network in Business Enterprises

In this subsection, the researcher recommends sequential steps to be taken into consideration in building DL or ML network for organizations. A summarization of these potential steps is presented in figure 2. Khaytin (2017) proposed some stages to deploy ML system in an enterprise.

Step one- Determining the enterprise's objectives, goals, and vision. This is the first and the very important step in DL system building process, to precisely determine the sources of data sets and the expected results that should be obtained.

Step two- Planning: it is the base of later steps. Planning the implementation and development of the system, in this step exploration of data patterns, knowledge, and sources will be done. And determining ANN architecture, DL method will be used (Supervised, Unsupervised, etc), and requirements of software and hardware that will interact in the system.

Step three- collecting and preparing data: collect data and determine sources of data sets. Data sources where data comes from differ in its form, for example, CSV, Excel files, APIs, or XML feeds. To improve effectiveness, data must be labeled with outcomes if known. It is important to define the initial weights of input variables in neurons, as they reflect seasonal demand fluctuations. the Preparation and Preprocessing

process depends on the model input requirements. It is preferable to have a larger amount of data, even if the data is inconsistent or has errors. This is better than having a small amount of "accurate" data. If the data is not enough, at this step, you can define which data will help solving the task and start collecting them. Previous and stored knowledge will be analyzed and explored too to be used as a source of new knowledge. The most valuable data is raw data, without aggregation and pre-processing. The preparing process transforms the raw data into a format that enables successful model training.

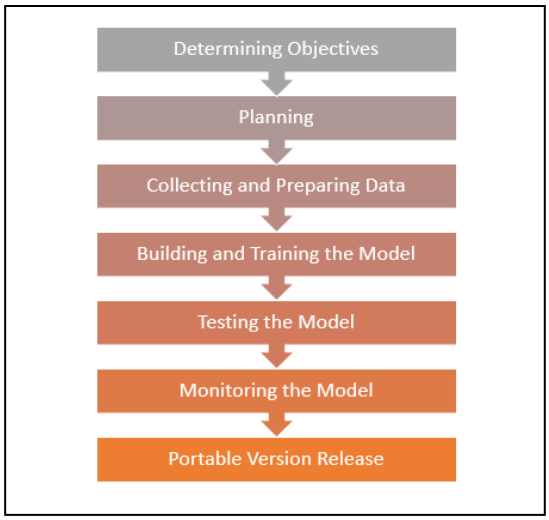
Step four- Building and Training the model: prepared data and knowledge from the previous step will be in use in this step, where data and knowledge analyst determines the factors that affect model of the system. Business experts and strategic managers in the organization and AI developers must provide help and guide to analysts to correctly use accurate data and knowledge to model the system in the most effective way. This step is the main step in building the system where ANN will be built, and DL algorithms methods will be programmed. To make sure that model's accuracy is in high levels, it is important to redesign the process of model training in a few months. So, accuracy will increase over time even though new factors affecting the organization may occur.

Step five- Testing the model: In this step, the system is tested by integrating the deep neural network with the original system of the organization to be ready for use. The interface must be simple and easy to use, as it will be used by all employees and clients. It is important to measure and test the accuracy of the system, by comparing the obtained results with what it is expected to be. DL algorithms do not present an explanation for why these results occurred, according to the high complexity degree of operations where there are many and many calculations are computed in the hidden layers (forward and backward), to finally get the outputs. By comparing the obtained results with the desired results experts can determine the necessary changes in DL algorithm or in calculations that are used in the different layers.

Step six- Monitoring the model: after training the system and making changes-if required-, the system will be in the final form and ready to use. This using requires continuous monitoring the quality, speed, availability, reliability, training on newly discovered knowledge or collected data, and the probability to update weights based on new reasons or factors in the environment, etc. The monitoring process is very important to ensure that the system is performing sufficiently well. It is worth mentioning that a stand-alone DL system with self-training capabilities is still in the research stage, and the need for experts' presence is important to ensure its success, especially in business industry world.

Step seven- Portable version release: This is optional step where the final system can be run on mobile devices. A portable version is needed when field work takes place in the organization, and many employees must work in different places. The conversion process to portable devices must produce a light and simple version, considering it will run on less processing power and less memory space. The main function of the portable version is only to conduct inferences accurately.

Figure 2. Steps of building business system with DNN (by researcher)



Section Six: Conclusion

This study has established the importance of applying DL and AI to enhance KM in business organizations. DL improves the overall performance of organizations' processes such as accounting, marketing, and manufacturing by increasing the effectiveness and efficiency of KM processes (capturing, discovering, sharing, and applying) which will reflect on high productivity, few mistakes, and high revenues. Using DL in KM leads to accelerate responses to customer demands and save costs. As illustrated in this research more data sets inserted (labeled or unlabeled) into Deep Neural Network and more hidden layers, will lead to more accuracy in results over time. There are many kinds of DL algorithms to choose from in business organizations, while choosing the best one is based on forms of data sets, kind of processing over knowledge, and problem domain or decision type to be taken. Many advices and steps are proposed to help organizations' experts in building their intelligent systems.

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