

Empowering deep learning based organizational decision making: A Survey

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Abstract: The advent of deep learning has revolutionized the landscape of organizational decision-making by offering powerful tools for data analysis and prediction. In this comprehensive survey, we explore the intersection of deep learning and organizational decision-making, elucidating the theoretical underpinnings, empirical evidence, and practical implications of this synergy. Theoretical foundations and research hypotheses are rigorously examined, providing a solid framework for understanding the role of deep learning models in enhancing decision-making processes. We delve into the systematic survey, which encompasses a wide spectrum of applications across various industries and domains, showcasing how deep learning empowers decision support systems, augments data-driven decision-making, and refines decision-making frameworks. Drawing inspiration from the Egyptian Vision 2030, we explore the implications of deep learning-based decision-making on national development strategies and policy implementation. Our analysis sheds light on the transformative potential of these technologies, offering insights into how organizations, particularly in Egypt, can harness these advancements to achieve their developmental goals. Finally, we outline future directions in this field, highlighting emerging trends, technological advancements, and potential areas for further research. As the digital age continues to reshape the landscape of decision-making, this survey serves as a valuable resource for researchers, policymakers, and practitioners seeking to leverage deep learning for empowered, data-driven, and informed organizational decisions.

Keywords: Deep Learning, Organizational Decision-Making, Machine Learning, Decision Support Systems, Organizational Intelligence, Data Analytics, Empowerment Strategies.

1. Introduction

During earlier decades, researchers in emphasized that organizational theory underwent a paradigm development as a result of Simon's groundbreaking work. Numerous studies [1] that employed the Carnegie methodology highlighted the importance of information processing and decision-making as foundational components in analyzing the organization's process and structural aspects. Accordingly, [2] significantly drew on information-processing theory (IPT), which aims to explain behavior by scrutinizing the information flows in organizations, to create an organizational profile of first movers and establish particular hypotheses. Wherefore, organizations are

Event	Date
Received	02-12-2022
Revised	05-06-2023
Accepted	08-06-2023
Published	15-06-2023

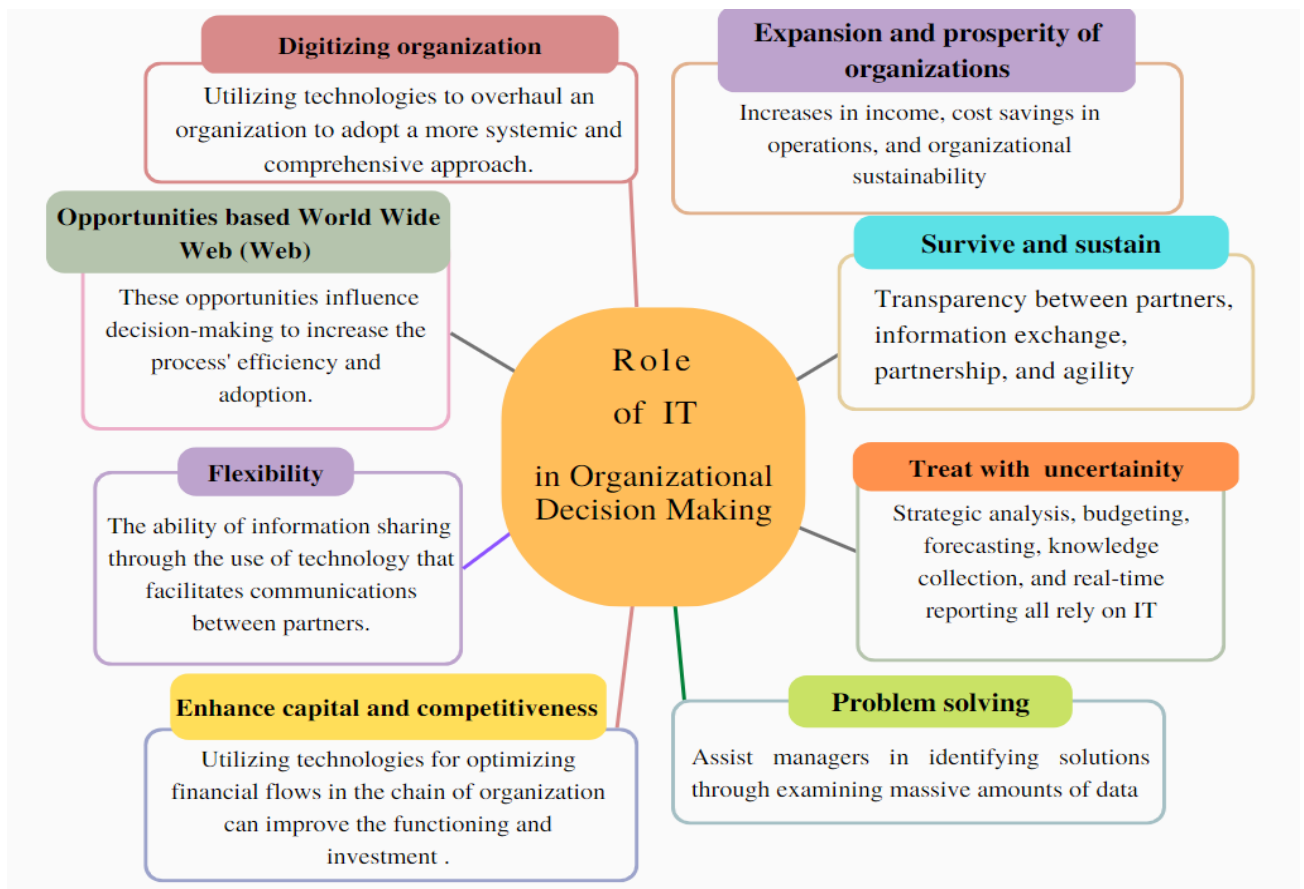


Figure 1. The implication of Information Technology on organizational decision making

characterized by the organizational IPT (OIPT)[3] as systems with the aptitude and obligation for processing information to mitigate volatility and uncertainty. 1 2

Several studies [4] have looked at how organizations utilize information, starting with Simon in 1947 and spurred by interest in how formal organizational structure affects decision-making. Tushman et al.,[5] referred to an organization's capacity to effectively use and organize information to assist decision-making through IP. Making decisions [6] involves the availability of high-quality information that serves as the foundation for decisions. So, other challenges, mostly brought on by the diversity of information and knowledge that is being manipulated, influence how human agents make decisions. Computerized information is modelling for supporting decision makers (DMs) in decision process and solving complicated problems refer to Decision support systems (DSS) [7]. According to [8] DSS applications and technology have advanced greatly since the early 1970s, and these advancements have provided the opportunity for DSS capabilities to become substantially more robust. Similarly [9] Previous decades have seen a significant increase in the use of cutting-edge technologies to assess organizational processes and effectiveness. The information technology (IT) plays vital role in the study of [10] for increasing the efficiency and effectiveness of a user's decision-making. 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

The significance and role of IT in organizational decision making (OrgDM) is summarized in following Figure 1. This figure illustrates the importance of utilizing IT in 19 20

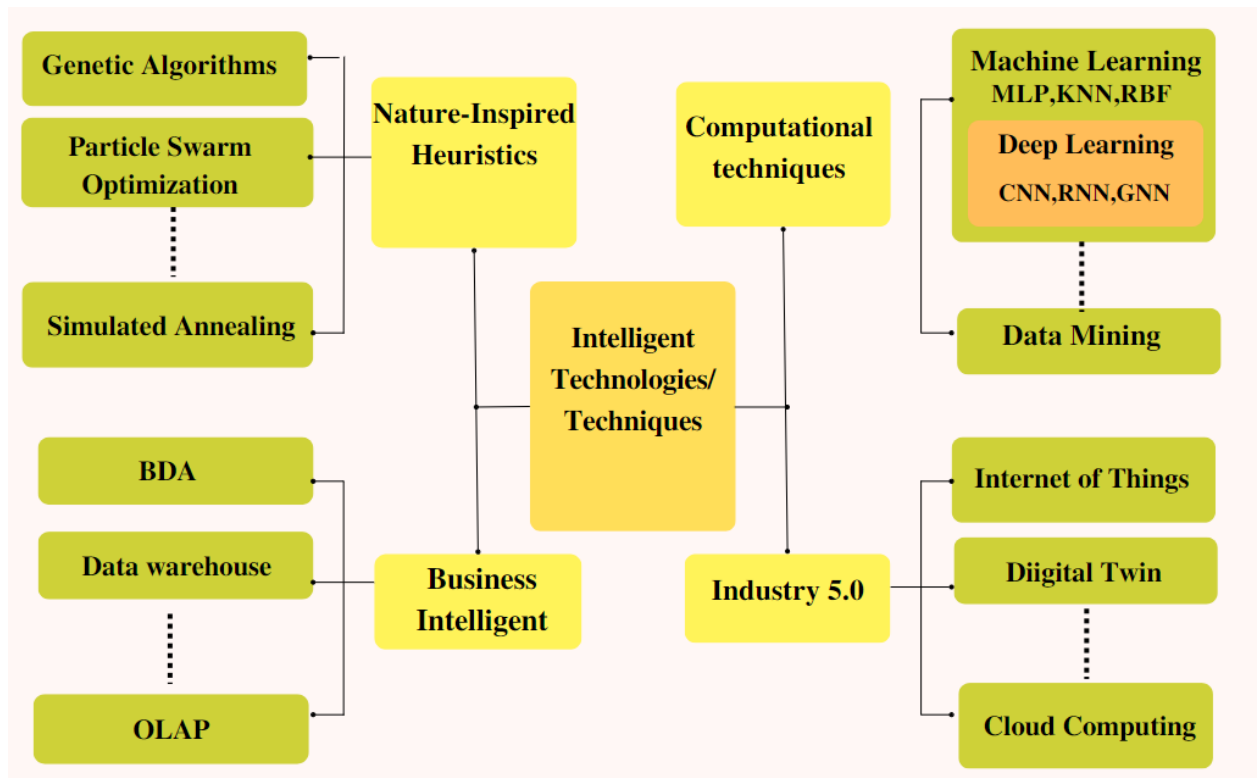


Figure 2. Branched Techniques and Technologies for automating decision-making

organizations based on the researchers' viewpoints [6],[11],[12] and its impact on the automation of decision-making based on data analysis and dealing with unstructured data.

The environment in which organizations operate [6] is extremely dynamic, immensely complicated, and constantly changing. In furthermore, this dynamic and complicated environment generates vast amounts of data characterizes by heterogeneous, complexity, and unstructured. Consequently, decision makers (DMs) are facing challenges and difficulties for making decisions in time constraint. According to these viewpoints about implication of IT on OrgDM, traditional organizations transformed into digital organizations through employing various technologies and techniques in different fields. These technologies are being applied for the purpose of replacing machines instead of human beings. This study illustrates these technologies and approaches of transformation to intelligent/smart organizations as following Figure 2.

According to the idea of organizational information processing [13] , information is one of the most crucial organizational resources. It presumes the way in which organizations are established, particularly their structures, procedures, and processes. Utilization of mentioned technologies and techniques to t are speed up the decision-making process and decision becomes automated and intelligent decision through analyzing and mining the information-based technologies specialized in these processes. Continuous revolution of industry until Industry 5.0 (Ind 5.0) encompasses technologies which add values in organizations' decision process as [14] Big Data Analytical (BDA) which positively affects the quality of decisions. Based point of view for [15] to gain insight and competitive advantages, information must be collected, stored, and analyzed. This

analyzed information is organized in regular structure form and visualizing it through Business intelligent techniques (BIT) especially online analytical processing (OLAP) which is illustrating analyzed information through dashboard. In [16] financial sector focuses on gathering and analyzing information regarding consumer behavior patterns. This gathered and analyzed information is treated as input for machine learning as clarified in Figure 2. These techniques are used to forecast demand of consumer in the next days through extracting and discovering new patterns/information from recent and historical information. Also, these techniques fall under umbrella of AI. The study of [17] expressed the concept of AI as the capability of a system to accurately understand external data, to learn from such data, and to use those knowledge gained to accomplish certain objectives and tasks through adaptability.

Consequently, employing techniques of AI in OrgDM [18] aide DMs to improve quality their decisions to be optimal. Advanced computational techniques of AI [19] are analogous to human intelligence which mimicking how the human brain thinks. Also, how nonhuman or intelligent agencies are learning from experience and modify their actions in response to new information. In the study of [20] Artificial neural network (ANN) is example of computational techniques and Deep learning algorithms (DLAs) is branch from ANN which learns hierarchical data representations via multiple layers of processing. DLAs in [21] contribute in enhancing the process of decision making for augmenting DLs based decision making. According to [22] attracting attention DLAs of various organizations for argumentative decisions as Google, Best Buy, and Cisco in its human resource (HR) department which targeted at promoting employee talent retention, engagement, and productivity. In this paper we focus on DLAs and its implication on OrgDM thus, we conduct survey related to our core. Also, we exhibit the potential benefits of utilizing DLAs to unstructured and equivocation data for management decision-making.

2. Theoretical background and research hypotheses

This section divides into two sub-sections. The first one elucidates the significance of the role that DLAs play in OrgDM through developing a set of hypothesizes. The second one illustrates a systematic survey about previous studies which applying DLAs and other techniques to enhance OrgDM.

2.1. Research hypotheses

This subsection illustrates how DLA boosts the process of decision making through hypothesizes for our new direction and conclusions based on previous studies.

Hypothesis 1: Influence DLAs on decision making in business domain.

The quantity of information [23] generated from IoT technologies as sensors, actuators, and other communication devices is characterized by a massive volume, velocity, variety, veracity, and value. This generated information considers formidable obstacle for decision making. Authors [24] demonstrated the significance of employing techniques for organizing and processing huge data efficiently and effectively. Recently DLAs consider most popular technique has ability to deal with this obstacle. As a result of its efficiency as mentioned in [24], it has been employed in [25],[26] to use and analyze historical stock

data for predictive purposes in the financial sector. Likewise [27] established a financial model using Environmental, Social, and Governance (ESG) ratings and Mean-Variance Portfolio Theory to construct a socially conscious investment portfolio (MV-ESG).

Hypothesis 2: Securing organization's financial statement via detector DLA(DDLA)

Current developments in DL [28] include Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN) which are extensively researched to handle different Natural Language Processing (NLP) applications. In general, DLA is able to identify semantic relationships and determine the intended meanings of various word and phrase combinations. Thus, DLA is ideally adapted to accurately identify fraudulent situations. The problem of financial statement fraud is discussed in [29] attempts to solve this issue through utilizing DLA in particular, hierarchical attention network (HAN) for purpose of extracting text features from Management Discussion and Analysis (MD &A). This architecture [30] is intended to encapsulate two fundamental principles of document structure. Firstly, hierarchical arrangement of documents. Secondly, it has been discovered that various words and phrases within a text have varying levels of informational value. The findings of [29] can support stakeholders' decision-making processes through textual information generated through HAN for improving the forecasting precision of financial statement fraudulence, especially in the generation of warning signals for fraudulent behavior.

Hypothesis 3: DLA optimizer for utilizing information in various organizational fields.

The study of [31] confessed that DL is a branch of ML known as deep learning. Compared to conventional ML models, the algorithms of DL are more sophisticated. This is due to the capability of DL for learning features of the data and tackling increasingly difficult issues. Thus, [32] applied DLA for treat with challenges of BDA as distribution is non static, vast volume, diverse, and disordered. It is crucial for discovering complex, beneficial patterns that were before unfathomable.

Hypothesis 4: Organization gain competitive advantage via DLA.

Organizational behavior [33] is influenced by DL. The term "digital trace data" appears through collecting massive amounts of information from various digital devices which can be collected and traced. The collected information is analyzed for certain purposes such as classification, clustering, and regression of analyzed information., more effectively examine and use special data characteristics. DL is discovering and exploiting interactions in information to predict future organizational behavior for boosting the competitiveness of organizations. For example [34] aiding with price predictions for the travel industry. DLA [31] may be applied in agriculture sector as a tool for the best planting, land usage, yield enhancement, production and disease.

Hypothesis 5: DLA's influence on organizational agility

Agile organization [33] refers to flexibility of organization to receive and analyze business's information of external market to assist organization's plan to change its strategy, strengthen its competitiveness, and improve performance. After that it takes

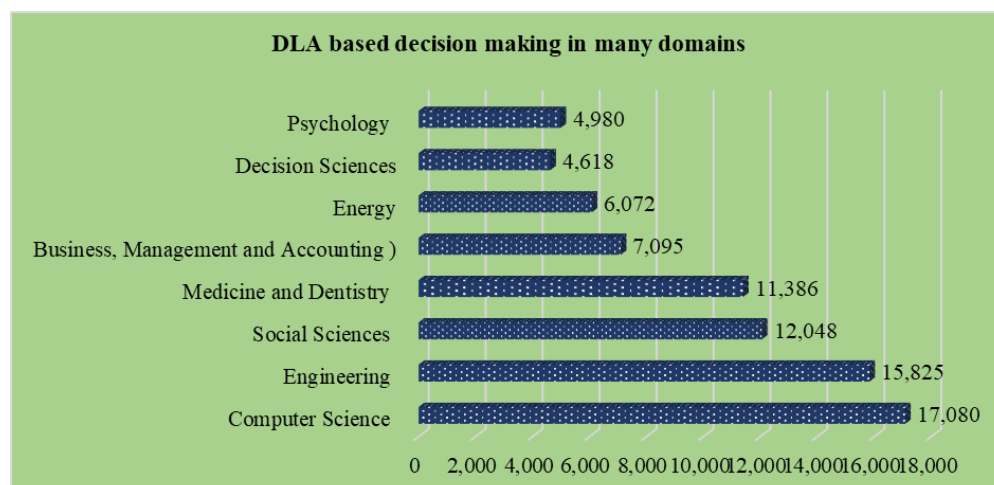


Figure 3. Application of Deep learning-based decision making in many domains

action (response) based analyzed information. This action represents in organization 1
 evolutionary as restructure organization, new product, collaboration with new partners, 2
 and gain customer satisfaction. To boost agility of organization, the organization is 3
 adopting effective techniques as DLA to support for making decisions, and to provide 4
 quicker and more precise response through gaining insight on how executives handle 5
 information collected. 6

**Hypothesis 6: Utilization DLAs in decision making for diverse domains and 7
 sectors 8**

As a result of human decision makers' limitations, technologies are merged in 9
 activities of organizations where these Technologies especially DLAs have the potential to 10
 boost data processing and analyzing velocity to improve. Figure 3 confirms DLA inclusion 11
 in various domains and sectors. This visualization is resulted from conducted survey in 12
 Scopus database on merging DLA with decision making in various domains. 13

3. Systematic survey 15

This sub section follows method of [35] to conduct a thorough analysis based Web 16
 of Science (WoS) database and Scopus for the literature from 2019 to 2023 covering the 17
 last five years for applying popular technique of DLA in decision making. 18

A. Publications per year. 19

We conducted a survey for published studies which related to our scope in two 20
 popular database WoS through research query based Boolean operators as (TI= (decision 21
 making)) AND TI= (deep learning), and Scopus and research query is conducted for certain 22
 period in certain periods (i.e., 2019-2023). 23

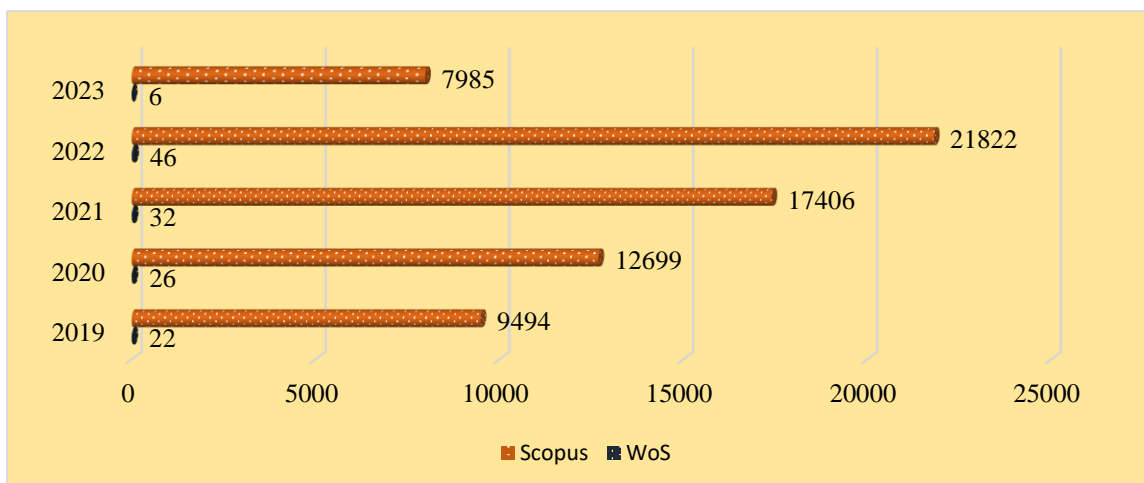


Figure 4. Publication for previous studies per years

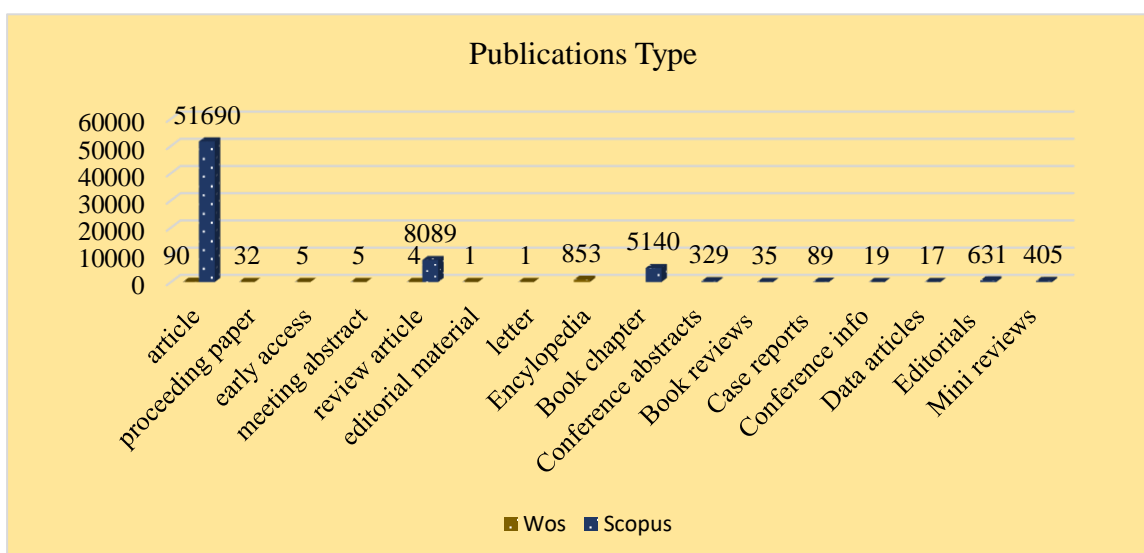


Figure 5. Publications type for previous studies

According to Figure 4, we observed that applying DL in decision making in the previous studies is constantly increasing with the increase of years either Scopus or WoS databases.

B. Publications Type.

The various types of publications which related to our interested direction of DLA based decision making and Figure 5 utilize for illustrating these publications. According to this Figure, Scopus database encompasses massive of publications related to our scope compared with WoS database.

4. Implication of Egyptian Vision 2030

Egypt seeks to improve its planning beginning with strategy until operational to achieve its a long-term vision to be sustainable in various domains in new Egypt “Egypt’s vision 2030”. The term of sustainability supported and related with many of pillars. Many studies as [36] illustrated the concept of sustainability is related to pillars as environmental or ecosystem, economic, and social. Also, the authors discussed the methodologies and techniques which aided DMs and experts to boost these pillars to achieve sustainability. There are other pillars as democratization, social equity, and Pacifism. The goals of “Egypt’s vision 2030” lies in the following points:

- Transform civilization's trajectory to become more sustainable and then achieving sustainable development (SD).
- Transform Egypt’s traditional methodologies and procedures into digital and automation methodologies and procedures (auto- methodologies/ procedures) through adopting supportive techniques for digitizing and automating as
- Evolutionary long-term planning and processes as making decisions in different domains to be agile according to environment change, uncertainty situations, and unstructured problems as crises.
- Adoption of such techniques in making decisions is aiding stakeholders through recommending optimal decisions (solutions) in various domains. Also, decisions become auto-decisions without human intervention.

To achieve “Egypt’s vision 2030”, Egypt adopts advanced and digital techniques as Artificial Intelligence Techniques (AITech) in its sectors and domains to enhance decision making. Recently, one of the most popular techniques of AITech is DLA. DLAs [31] outperform shallow ML techniques in terms of speed and efficiency. Due to [37] Many hidden layers in DL allow it to learn the features of input and tackle increasingly challenging issues. Influential DLAs in Egypt to achieve Egypt’s sustainable development (Egy-SD) in sectors of Egypt is illustrating in following Research Questions (RQs):

RQ₁: How adopting DLAs supporting Egypt to be proactive and acquisition agility?

The capability of DLAs to predict future behaviors and events. So, it can utilize in Crisis Management through analyzing and training massive of received and historical data. Thus, DLA becomes responsive through executing for decision making.

RQ₂: How DLAs are better than human intervention as DMs and stakeholders in decision making ?

With the purpose of enhancing decision-making for different fields [21], DLAs have been used to extract information through using sentiment analysis for social media and financial news for recommending optimal decision. Its ability to deal with non-linear dataset and dynamic environments [38]. So, DLAs solve complex problems which humanity cannot solve.

RQ_r : How DLAs transform Egypt into digital Egypt ?

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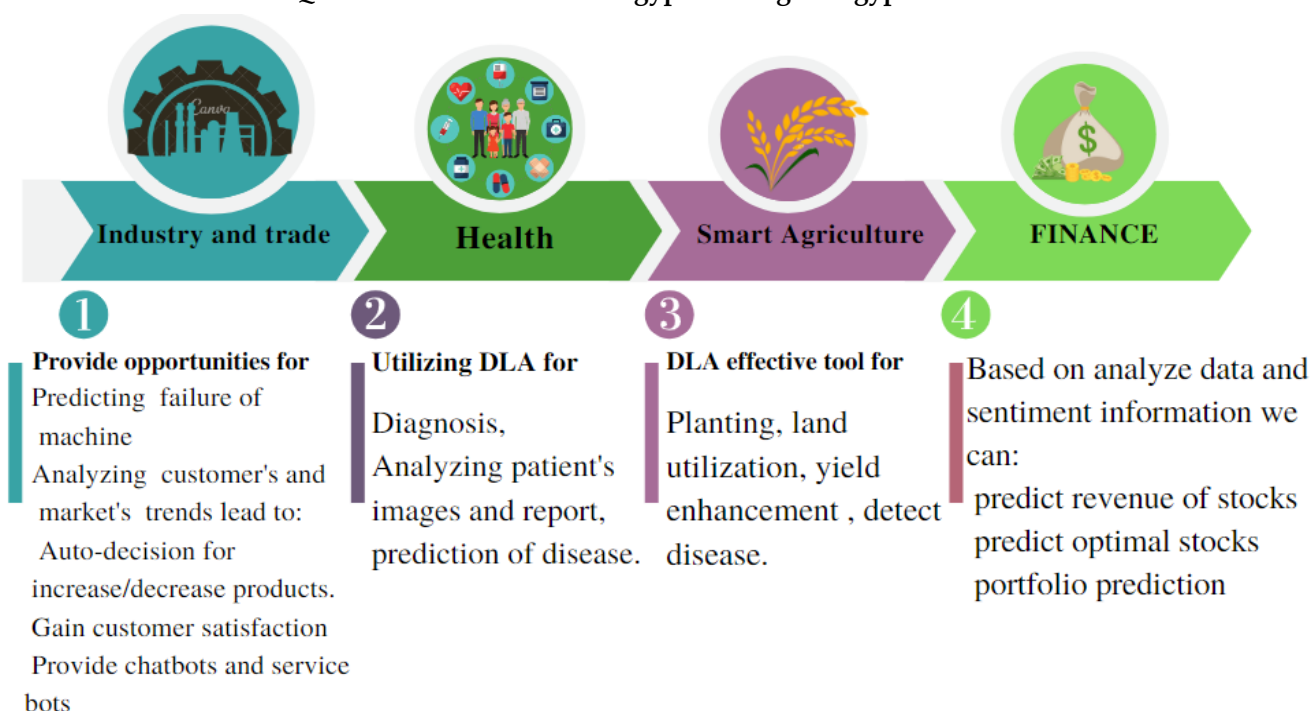


Figure 6. considers robust motivator for DLAs

DLAs have a positive impact for transformation into digital Egypt in many sectors as:

- Employing DLAs in different organizations and sectors in Egypt to gain it competitive advantage.
- Make these organizations agile for an environment which is characterized by continuous changes, complexity, and dynamic.
- Egypt becomes sustainable then be Egy-SD for achieving "Egypt's vision 2030".

5. Future Directions

In the ever-evolving landscape of deep learning, one promising avenue for future research lies in advancing the interpretability and explainability of AI models. As organizations increasingly rely on complex deep learning models for critical decision-making, the need to understand and trust these models becomes paramount. Future research should focus on developing methods and tools that provide clear and interpretable insights into the decision-making processes of deep learning models. This could enhance their adoption in industries where transparency and accountability are crucial.

As deep learning continues to shape organizational decision-making, ethical concerns surrounding bias, fairness, and accountability become more pronounced. Future research should delve into the development of ethical guidelines and frameworks specific to deep learning applications in decision support systems. Exploring techniques for bias

mitigation, fairness assessment, and ethical decision-making can pave the way for responsible and socially beneficial AI adoption.

The synergy between deep learning and organizational decision-making often requires cross-disciplinary expertise. Future research should encourage collaboration between experts in machine learning, decision sciences, and domain-specific fields. This interdisciplinary approach can lead to innovative solutions tailored to the unique needs of various industries and facilitate knowledge transfer from AI research to practical organizational contexts.

Scalability and resource efficiency are crucial challenges in deploying deep learning models in real-world decision-making scenarios. Future research should explore methods to optimize model architectures and training processes, making them more resource-efficient without compromising performance. Additionally, investigating techniques for transferring knowledge from pre-trained models to specific decision domains can reduce the computational overhead and facilitate broader adoption.

6. Conclusions

In the era of digital transformation, the symbiotic relationship between deep learning and organizational decision-making has emerged as a transformative force. Through this survey, we have traversed the landscape of deep learning applications in decision support, unveiling its potential to empower organizations across various domains. The theoretical foundations and research hypotheses laid the groundwork for understanding how deep learning models enhance decision-making processes, while the systematic survey illuminated a broad spectrum of applications, showcasing their versatility and effectiveness. The implications of deep learning-based decision-making for Egypt's Vision 2030 underscore the importance of harnessing these technologies for national development strategies. As organizations strive to navigate a data-driven world, the insights derived from this survey can serve as a valuable guidepost. However, it is crucial to acknowledge that this field is in constant evolution, and its continued growth demands a commitment to addressing ethical concerns, promoting transparency, and fostering interdisciplinary collaboration. As we look to the future, the dynamism of deep learning and organizational decision-making presents both opportunities and challenges. The path forward involves embracing advancements in interpretability, navigating ethical complexities, nurturing interdisciplinary partnerships, and optimizing resource usage. By doing so, we can ensure that deep learning remains a powerful ally in driving informed, empowered, and responsible decision-making in organizations, ultimately contributing to a brighter and more data-centric future.

Supplementary Materials

Not applicable.

Author Contributions

All authors contributed equally to this work. 1

Funding 2

This research was conducted without external funding support. 3

Ethical approval 4

This article does not contain any studies with human participants or animals performed by any of the authors. 5
6

Conflicts of Interest 7

The authors declare that there is no conflict of interest in the research. 8

Data Availability Statement 9

All data generated and analyzed during this study are included in this manuscript. 10

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