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ADSS: Automated Decision Support Systems

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ABSTRACT

Machine intelligence comprises the components that drive the world to the next generation. Its applicability has expanded hugely particularly in automation. Automated teller machine, Robotics, Heuristic Internet search, and decision support systems constitute the most successful applications. Experts are however working on the sections to develop more sophisticated systems. Decision Support Systems have aided in the growth of firms through information review such as customer, product, employee, and market analysis. Besides, timely information obtained through data warehousing assist the management in swift decision making to avert situations leading to high business success. This paper elaborates on the automated decision support systems ADSS and their applications resulting in the analysis of its components, historical advancements, models, frameworks, applications and benefits. Also, it further discusses the Artificial Intelligence components, applications, and limitations one of the most important pillars of ADSS.

Key words—Decision Support System; Automated Decision Making (ADM); Cognitive Science Applications; Expert Systems (ES); Business Intelligence (BI)

1. INTRODUCTION

Decision Support Systems DSSs find applications in every field; they are gaining high applicability leading to extensive researches. Indeed, DSSs through intelligent machines will drive the world into the next computing generation [1] . However, the field has the attention of experts and the potential unveiled with the emphasis of chances to identify more applications. In the machine intelligence, DSSs form the most vital aspect. It comprises components such as Artificial Intelligence AI that enable decision automation based on existing facts, knowledge base, expert approach, and user/expert input. Decision automation implies that computer is used in the process of making decisions. The business rules coupled with the programmed instructions are triggered by input and events whereby the program consequently makes the contingent choices [2, 10]. Most of the papers done on this subject do not fully cover the concept of ADSS including its components and applications. This paper aims at comprehensively discussing the automated decision support systems through analysis of its primary components and applications. The paper reviews some of the best works detailing decision based systems and their automation. It focuses on the concept of automated decision-making systems and the tools behind its success. To comprehensively understand the decision making system, the most popular pillar principle of automation are considered, the Artificial Intelligence (AI). Figure 1 reflects the order of the paper sections and their content.

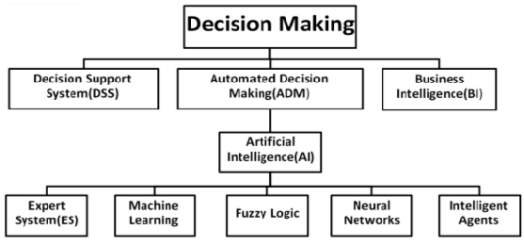

Figure 1: Decision Making Hierarchy.

2. RELATED WORK

In 2005, Thomas [3] identified the new features in the automation of decision making and the positive effects associated with it. One of the findings is that automation works efficiently for fast, frequent, and well-stipulated challenges. The outcomes formed a solid foundation for researchers, particularly for the evolving part of the concept. A further investigation aimed at identifying the significance of integrated DSS [4]. The study focused on integration concerns of DSS and how it influences the current world. The automation features are mentioned as a far-fetched theme in the study and only examples depicted. However, the study hints on the importance and enormous effects automated DSS have in the general operations. Eventually, the research calls for more research on the adaptability aspect of the IDSS. The growing reliance on data impacts dynamic data extraction and retrieval of the relevant information. It also affects the analysis, storage, and application of the data. Earlier, data formed a small portion which was easy to interpret, manipulate, and utilize. However, the current world produces a massive amount of data that needs to employ intelligent techniques through automated decision systems. The study conducted by Das [5] illustrates that there are numerous applications for intelligent DSS ranging from industrial, entertainment, medical, and the web.

3. DECISION MAKING

Decision-making process aims at a choice of the best option among some alternatives. Equally, every firm relies on decisions made at every stage to thrive. As a result, businesses invest heavily in the decision process. A choice is characterized as the decision of one among various options, and decision-

production is the investigation of distinguishing and picking different options to locate the best arrangement in light of multiple components and considering.

A. Decision Making Styles

Choice style has been conceptualized as an esteem introduction/individual, respect that structures four original styles portraying four blends of modus operandi: (a) Directive, (b) Analytical, (c) Conceptual, and (d) Behavioral. These methods make Rowe and Mason Cognitive Complexity Model (1987) [6]. The model comprises four chief styles namely (1) The Directive style, that portrayed by low resilience for vagueness and profound psychological multifaceted nature. The introduction is centered on assignment and specific concerns. (2) The Analytical style, that portrayed by tremendous resilience for vagueness. (3) The Conceptual style that is characterized by high resilience for uncertainty and high intellectual many-sided quality. (4) The Behavioral technique, that portrayed by low resistance for vagueness and profound psychological multifaceted nature.

B. Levels of Decision Making

The strength of an organization relies on the ability to make strong and reliable choices. This is because approach towards decisions determines the setting of objectives, line of investment, resources invested, as well as policies. Particularly in predicting the environment of operation and matching either the context of the characteristics of the organization or vice versa. Though decision involved all levels of management. The management principally initiates the process aiming at how efficiently, and productively the firm engages the allocated resources particularly the decisions and ideas. As a result, the management decisions are carried down to the implementers hence the need for close interaction and monitor on the implementation. Experts utilize Knowledge-based which contributes to choices particularly identifying, analysis, and evaluation of ideas for products and services. It's also involved in alternative approaches to the communication of new knowledge as well as information sharing with stakeholders. [17].

4. DECISION SUPPORT SYSTEMS (DSS)

Based on the importance and repercussion of the choices, firms seek the support of a system in their choosing. Decision Support Systems (DSSs) are therefore solutions that serve the management in their decision-making process. DSS by default comprise interactive features to aid sufficient data and model analysis with the intent to classify and resolve predicaments as well as present resolutions. Decision Support (DS) is a broad field worried that is a piece of Decision Sciences. It offers with regularizing and engaging ways to deal with primary decision-making [8].

A. DSS Components

DSSs need to be integrated with new technologies, business environment and processes to improve decision support performance. The subject of integration can involve data format, user interface, sharing functions, and other aspects of DSS construction. To achieve proper integration, a DSS should consist of some capability components. All DSS comprise four standard components: information, model, knowledge and user interface management sections.

Data administration focuses on the storage, manipulation, and maintenance of information necessary. The sources include either one or a combination of the following: The primary source of information, External sources and Personal information.

The second component, the model, refers to the analytic tool that is the part responsible for analysis. It includes financial, statistical, management science, or other quantitative models that support data analysis as well as system maintenance.

The third component is knowledge-based KB management subsystem. It provides information pertaining data and their relationships, particularly complex data. It comprises possibilities, alternatives, rules, and methods of evaluating options to arrive a decision. In most organizations, many AI systems are executed on web-based developments.

The fourth element, user interface subsystem. The sole intent of the user interface is to present a mechanism within which the user and the DSS may communicate. DSS is interactive and therefore requires massive user communication [9].

B. DSS Classifications

According to Simon (1960) [7], choices may either be programmed and non-programmed. Alternative sources classify this regarding structure. Three classifications are derived concerning structure as Structured, Semi-Structured, or unstructured. For the unstructured DSS, the user becomes the prime contributor and decision maker. On the contrary, structured decisions represent a routine, repetitive and procedural process of decision-making. Semi-structured has a clear cut solution provided by accepted procedures.

C. DSS Phases

Based on Simon's principle [4], decision-making means constitutes three stages namely capacity, scheme, and decision. Intelligence/capacity that forms the first step comprises problem identification. Design stage focuses on identification of possible alternatives to find the best solution. Choice aims at evaluation of the alternatives to identify the best option that is implemented. The model has gained high acceptance and commonly referred to as intelligence-design-choice. However, later on, Simon added a fourth step, monitoring phase. Gerrity et al., [4] researchers from MIT, contributed heavily towards DSS. The phases include examination, plan, actualization, assessment, and evolution. Nevertheless, the study on DSS has diverse approaches.

D. DSS Driven Sources

Different categories of DSS function to meet specified goals utilizing different approaches and thus focus on a broad target. Table 1 shows a close comparison of the various categories of DSS against common factors. It creates a clear

distinction between the classes complementing the discussion in this paper.

5. AUTOMATED DECISION MAKING (ADM)

To fully comprehend the DSS, it's important to consider the Automated Decision Making (ADM) and its constituents. AMD shapes the future of decision making. So, it is important through this research to discuss all facets related to this.

A. Automated Decision Making Foundation

Automation refers to the utilization of machines with minimal human monitor and input to achieve the tasks in more efficient ways. Notably, ADM focuses on technological applications to develop efficient systems surpassing human ability in speed and accuracy. Automatic Teller Machine ATM which is a global success in the service industry rely on ADM [11]. Automated systems may not be left to work entirely on their own. The automation is based on clear decision-making paths. Besides, it guides the user in information gathering.

B. Automated Decision System Framework

The generation of consistent decisions requires that there are structured, coherent processes to be defined. These processes lead to the advent of decision-making framework. The major objective of decision making is to process uncertainties, evaluate options and finally assess the potential consequences of a particular decision. The decision-making process is comprised of eight distinct steps [12].These steps comprise of Definition of the problem, Determination of the requirements, Establishment of goals, Identification of alternatives, Development of evaluation criteria, Select decision-making tools, Select preferred alternative, Validate perceived solution

C. Automated Decision System Models

Today, various automated decisions models are in use varying with the intended goals. They include custom drivers, enterprise-precise ensembles, mathematical algorithms, workflow, and company programs. Condition-oriented method, define a set of firm rules which utilize declarations. Statistical is also referred as numerical algorithms focus on quantitative data processing to get an optimal choice [3].

D. Automated Decision System Tools

First, there is statistical decision theory that makes use of statistical knowledge to make a decision [12]. It makes use of sample information through data from statistical investigation while making inferences regarding their use. Consequently, decision-making combines sample information and other relevant aspects of the problem in order to make the best decision. The second tools used for decision systems is the expert systems and the rule-based decision modules.

6. ARTIFICIAL INTELLIGENCE

"A field of study based on the premise that intelligent thought can be regarded as a form of computation—one that can be formalized and ultimately mechanized."[13]. "Artificial Intelligence (AI) is the intelligence of machines the science and engineering of making intelligent machines, especially intelligent computer program." [14]. Warren and Pitt's work [15] were the first to be recognized in the field of AI. AI has been used lately in medical sector by analyzing patient data and recommending the best treatment that was proven to be 50% more effective. So AI is used to improve decision-making in deferent sectors. A DSS with embedded AI techniques is referred to as intelligent decision support system.

7. EXPERT SYSTEMS (ES)

Expert system (ES) is a part of AI applications. Expert system is program that mimics the actions of a human expert in making decisions. The main idea of ES is that expertise, a huge amount of domain-specific knowledge, is moved from a human expert to be stored in a computer. The computer can provide specific conclusion, advices, and explanations, if needed, of the logic behind it. The typical characteristic of the ESs is the skill to efficiently use uncertainty of unconventional models in indeterminate frameworks [16]. These components are: user interface, explanation mechanism, inference engine, knowledge base, and database of facts.

A. ES Components

In Figure 2, it is illustrated that ES is composed of three main components:

1) *Knowledge Base*: it contains the required knowledge to apprehend, formulate, and solve the problem.
2) *Inference Engine:* it is the brain of the system. It is responsible for all the tasks that require reasoning. It matches antecedents of the user's responses with firing rules.
3) *User Interface:* a method for the computer to communicate with the user.

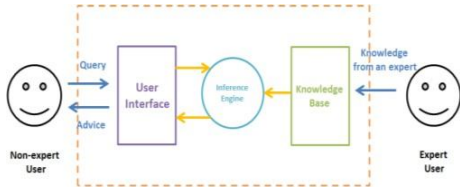

Figure.2. ES Components.

A. ES Representation Methods

Representation of knowledge can be done through several techniques. In this section, we will list the different methods for knowledge representation in ES.

1) *Knowledge Based ES:* is built on the concept of making a decision based on the comparison between the current knowledge and the knowledge stored in the database. In Figure 3, the core of a knowledge based system is illustrated.
2) *2)Rule Based System:* represents the rawest representation of AI. This type of systems utilizes rules when the knowledge representation is coded into the system.
3) *Frame Based ES:* frames represent a data structure with knowledge about a specific concept. Frames represent and capture knowledge in a frame based ES.

Table 1:
Comparison Summary on Decision Support Systems Driven Sources

Comparative Points	**Data-driven DSS**	**Document-driven DSS**	**Model-driven DSS**	**Knowledge-driven DSS**	**Communication-driven DSS**
User Interaction	User interacts primarily with the data	User groups in this type of DSS is expanding	User interacts primarily with a (mathematical) model and its results	User interacts primarily with each other(internal users) and new entries(new customers)	User interacts primarily with each other to perform a shared task
Problem structure	Contributes to solve inherently unstructured problems	Helps to solve mainly unstructured problems	Helps to solve well-defined problem (what-if-analysis)	Helps to solve formal problem	Contributes to solve unstructured problems
Model	Contains, in general, simple models	Contains a combination of different models	Contains in general various and complex models	Contains systems of different models	Contains a combination of different models
Data	Large amounts of data are crucial	Sifts through vast volumes of unsorted data	Large amounts of data are not necessary	Large amounts of data are crucial	Large amounts of data are not necessary
Purpose	Helps to prepare decisions by showing developments in the past and by identifying relations or patterns. Also, to query a database or data warehouse to seek specific answers for specific purposes.	Helps to search web pages and find documents on a specific set of keywords or search terms.	various to understand the impact of decisions on organizations	Helps to provide management advice or to choose products/services.	Helps to conduct a meeting, or for users to collaborate.
Targeted users	Managers, staff and also product/service suppliers	Broad base of user groups	Managers and staff of a business, or people who interact with organization	Users interacting and within an organization	Internal teams, including partners
Focus	emphasizes access to and manipulation of a time-series of internal company data and sometimes external and real-time data	emphasized on providing document retrieval and analysis through the use of computer storage and processing technologies	emphasizes access to and manipulation of financial, optimization and/or simulation models	emphasizes on suggesting or recommending actions to managers through person-computer systems with specialized problem-solving expertise	emphasizes on communications, collaboration and shared decision-making support
Basic functionality provided by	Simple file systems accessed by query and retrieval tools	A search engine	Simple quantitative models	knowledge about a particular domain	A simple bulletin board or threaded email
Initial example	Data-oriented DSS, Analysis Information Systems, and Retrieval-only DSS	Text-oriented DSS	Model-oriented DSS and Computationally oriented DSS	Suggestion DSS and Knowledge-based DSS	Group Decision Support Systems (GDSS) and SAMM system
Technology deployed	The main frame system, client/server link, or via the web	The web or a client/server system	Software/hardware in stand-alone PCs, client/server systems, or the network.	Client/server systems, the web, or software running on standalone PCs.	A web or client server

Table 2:

Comparison summary of ADSS concepts

Comparative Points	Artificial Intelligence	Experts Systems	Machine Learning	Fuzzy Logic	Neural Networks	Intelligent Agents	Business Intelligence
Definitions	These are systems that simulate human intelligence such as the ability to learn and reason.	An interactive system that seeks to imitate a human expert in a particular field. Important in addressing unstructured problems where there is a shortage of local human experts [5].	Field of artificial intelligence that deals with pattern recognition. It uses a variety of algorithms to evaluate a set of data and predict future occurrences. It is data drive and data oriented.	A form of artificial intelligence that deals with imprecise data and data that has a variety of solutions. Uses soft linguistic system variables such as hot and tall among others. It also uses a range of truth values as compared to the common true, false notation [5]	A neural network is an inter-connected assembly of simple processing elements, units or nodes, whose functionality is loosely based on the animal neuron. Connection strengths, or weights, obtained by a process of adaptation to, or learning from, a set of training patterns.	an intelligent agent is one that is skilled of flexible autonomous action to meet objectives of its design[15]	These Business intelligence provides the management with the information regarding the status of the organization and the best methods to steer it into the intended direction.
Uses and technology	They learn from experience and use reasoning to solve ambiguous and contradictory information's while using reasoning to make decisions effectively.[15]	Has three components namely the knowledge base that consists of facts and relationships. Second inference engine that consists of if/then decision. Finally, the dialog that the user enters the current problem which queries the knowledge database for an optimal solution for the user [5].	Problem-solving learning accumulates experience regarding rules and their contribution towards the correct advice. Case-based learning for collecting cases in the knowledge base and solving problems by asking similar cases. Inductive learning from examples.	Mainly used for systems that are difficult to model and controlled by a human operator or an expert system or when there are chances of ambiguity or vagueness [5]	Neural networks are often used for statistical analysis and data modelling, in which their role is perceived as an alternative to standard nonlinear regression or cluster analysis techniques. they are typically used in problems that may be couched in terms of classification, or forecasting.	Used to support in searching, filtering, and deciding what is related to the user. intelligent agents observe and reply in a time to changes that occur in their environment in order to satisfy their design objectives. Also, it's skilled of interacting with other agents and humans through cooperation and negotiation.	It provides the executive with the organizational, critical success factors [19].
Application in automated decision making	Help decision makers to select actions in real time. Reduce information overload. Dynamic response with intelligent agent. Deals with uncertainty in decision problems. Enable communication for collaborative decision.	Automatically collect, transmit, and analyze data from remote areas. Monitor operations, detect abnormalities, and suggest actions[18].	To make predictions, Use available data. The decision making under uncertainty. reinforcement machine learning Use to learn how to action when given punishment signals.[13]	Model the cause-and-effect relationships. assess the degree of risk exposure and rank the key risks in a consistent way. considering both the available data and experts opinions.	Can be considered to play the role of the "quantitative models" in model-driven decision support systems. Forecasting and analyzing past data.[15]	Response to changes in the surrounding environment in order to meet it's design goals. It makes designs according to the circumstances [15]	Extract data from one or more different sources and subject matters. Formatting the data for a report or graphical representation. BI applications provide users with the capability of multidimensional analysis.

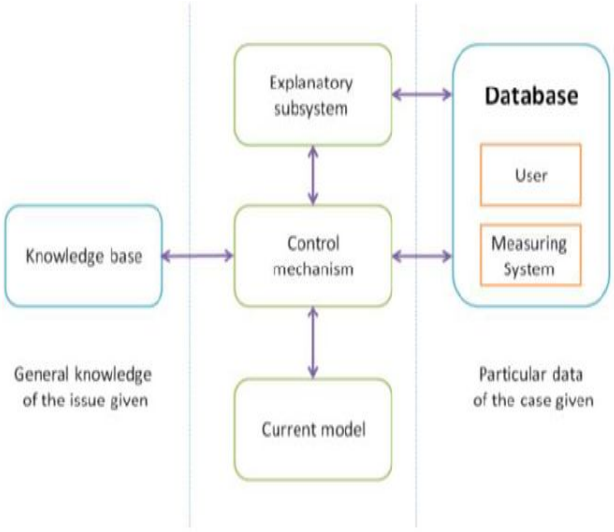

Figure 3: Knowledge Based System Scheme.

8. BUSINESS INTELLIGENCE (BI)

Another tool used for making decisions is Business Intelligence (BI). BI systems are considered a modern evolution and a descendent of DSS that cover the same functions. However, BI covers a broader scoop of applications which includes DSS, Knowledge Management System (KMS), Management Information System (MIS), Online Analytical Processing (OLAP), and Data Mining.

Business intelligence is the process of collecting, analyzing, and presenting data in a set of high-level representation of information. BI is a way to improve the performance of the business by assisting executives to make informed decisions. BI can also be defined as the process of collecting, treating, and diffusing the valuable information to reduce any uncertainty in making strategic decisions. Some of the BI characteristics are: possession of advanced analytical methods, collection of data, and support of demands from multiple users.

BI systems consist of three main technology components: data warehouse/marts as a source of data, Business Performance Management (BPM) to monitor the overall performance and user interface [17]. Data warehouse/marts support the integration, aggregation, cleansing, and query tasks of the numerous enterprise records to propagate the data. On the other hand, data marts has operational data which allows experts to come up with strategies. Business Performance Management (BPM) includes: target management, performance management, and resource management.

9. RESULT SUMMERY AND CONCLUSION

Taking the right decisions is critical for business growth therefore ADSS has been developed to help decision makers to make the best decisions. We found that ADSS is associated with other concepts that share its idea in the real world such as DSS and BI. In addition, ADSS implements different technologies related to AI. Stability, success, and operability of any enterprise rely heavily on the decision-making process. Traditionally, the process faced challenges such as time limit, increased consumption cost, unavailability of board members, and uninformed decisions. However, automation of the decision process through DSS covers most of the challenges. Through implementation of AI in the decision, more reliable solutions are sought. As a result, ADSSs and AI will drive the world. Table 2 summarizes these related concepts; where a brief comparison between them.

REFERENCES

[1] The 15th International Conference on Advanced Robotics, Tallinn University of Technology, Tallinn, Estonia, June 20-23, 2011

[2] D. J. Power, "What is decision automation?," 18 August 2014. [Online]. Available: http://dssresources.com/faq/index.php?action=artikel&id=6. [Accessed 4 December 2016].

[3] P. Lambin, Ruud G. P. M. Van Stiphout, M. H. W. Starmans, E. Rios- Velazquez, and A. Dekker, "Predicting outcomes in radiation oncology—multifactorial decision support systems," *Nature Reviews Clinical Oncology*, vol. 10, no. 1, pp. 27–40, 2012.

https://doi.org/10.1038/nrclinonc.2012.196

[4] S. Liu, A. H. B. Duffy, R. I. Whitfield, and I. M. Boyle, "Integration of decision support systems to improve decision support performance," *Knowledge and Information Systems*, vol. 22, no. 3, pp. 261–286, Jun. 2009.

https://doi.org/10.1007/s10115-009-0192-4

[5] "Expert Systems and Applied Artificial Intelligence", *Umsl.edu*, 2016. [Online]. Available: http://www.umsl.edu/~joshik/msis480/chapt11.htm. [Accessed: 10- Dec- 2016].

[6] A. A. Al-Omari, "The Relationship between Decision Making Styles and Leadership Styles among Public School Principals," International Education Studies, vol. 6, no. 7, 2013.

https://doi.org/10.5539/ies.v6n7p100

[7] "Levels of Decision making." [Online]. Available: http://www.maths.tcd.ie/~nora/ft351-3/dss.pdf.

[8] "What is Decision Support? -amattos.eng.br." [Online]. Available: http://amattos.eng.br/public/livro_si/bibliografia/whatisds5.pdf. [Accessed: 12-Nov-2016].

[9] E. Turban and J. E. Aronson, Decision support systems and intelligent systems. Upper Saddle River, NJ: Prentice Hall, 2007.

[10] D. J. Power, "A Brief History of Decision Support Systems". DSSResources.com, version 4.0, 10- March - 2007. [Online].available:

http://DSSResources.COM/history/dsshistory.html. [Accessed: 26-Nov- 2016].

[11] "What is an automated system?," Reference. [Online]. Available: https://www.reference.com/technology/automated-system- c85583d0f17a632. [Accessed: 28-Nov-2016].

[12] S. M. Cetiner, M. D. Muhlheim, G. F. Flanagan, D. L. Fugate and R. A. Kisner, "Development of an Automated Decision-Making Tool for Supervisory Control System," OAK RIDGE NATIONAL LABORATORY, Oak Ridge, Tennessee, 2014.

https://doi.org/10.2172/1252136

[13] Sarbjeet Singh and Sukhvinder Singh, "Artificial Intelligence," International Journal of Computer Applications, vol.6, no.6, pp. 0975 – 8887, Sep. 2010.

[14] P. Swarup, "Artificial Intelligence," International Journal of Computer and Corporate Research, vol.2, no.4, ID: ISSN2249054X-V2I4M4- 072012, July. 2012.

[15] A. Pannu, "Artificial Intelligence and its Application in Different Areas", International Journal of Engineering and Innovative Technology (IJEIT), vol.4, no.10, pp. 2277-3754, April 2015.

[16] N. Kaur, "Review of Expert Systems based on Fuzzy logic," Review of Expert Systems based on Fuzzy logic, vol. 2, no. 3, pp. 1334–1339, Mar. 2013.

[17] K. P. Tripathi, "A Review on Knowledge-based Expert System: Concept and Architecture," IJCA, pp. 19–23, 2011.

[18] C. Grosan and A. Abraham, "Rule-Based Expert Systems," in Intelligent Systems, Springer Berlin Heidelberg, 2011, pp.149–185.
https://doi.org/10.1007/978-3-642-21004-4_7

[19] K. P. Murphy, Machine learning: a probabilistic perspective. Cambridge, MA: MIT Press, 2012.