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AI in BI - A Conceptual Framework

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Abstract: Artificial Intelligence (AI) is a rapidly evolving field with numerous applications, some of which are in the domain of Business Intelligence (BI). While BI has got a good conceptual framework, the applications of AI in BI are quite fragmented and the pace of development is rapid. The AI and BI product organizations tend to focus on the benefits of their respective products. But, a conceptual framework for AI in BI which includes them in a meaningful way is still lacking. This paper aims to provide the same, along with examples from the Business Domains.

Keywords: Business Intelligence; Artificial Intelligence; Framework; RDBMS; Data warehouse

I. A BRIEF HISTORY OF BUSINESS INTELLIGENCE (BI)

BI has gained considerable popularity over the past decade. Although the term was first introduced in 1965 and picked up momentum in the mid-late 1980s, it was only in the early 1990s that the phrase entered public discourse.

The emergence of Relational Database Management Systems (RDBMS) was a significant step forward in the 70s. Edgar Codd, in his paper, "A Relational Model of Data for Large Shared Data Banks" [1], completely transformed the way databases were conceived from "a simple means of organization" to, "a tool for querying data to find relations hidden within." In the late 1980s and early 1990s the RDMBSs really took off. The term "data warehouse" emerged in the 70s and would ultimately change the way business intelligence would operate, says Furhaad Shah [2]

In the 1980s, "business data warehouse" was developed by IBM. It was intended to provide an architectural model for the flow of data from operational systems to decision support environments.

Data that had previously been spread across numerous sources like Online Transaction Processing (OLTP), historical repository of data and external sources could now be held together in one place with data warehousing. This allowed business users to search the information efficiently and to gather an overarching strategic picture of their model and functions. [3]

Over the years, Extract, transform, and load (ETL) utilities were developed to move data from disparate data sources, transform them into the common data warehouse format and then load them to a common data warehouse. [3]

These warehouses were specifically designed to support the analytical functions required for business intelligence (OLAP, or online analytical processing), making it possible for users to execute rapid and complex analytical queries.

The BI landscape has grown from a competition between a handful of competitors to a booming and highly successful market.

II. BI FRAMEWORK – FROM DATA TO DECISIONS

BI can be termed as a journey from Data to Decisions. The Data Warehousing Institute (TDWI) had formalized a BI framework which describes this journey in precise terms. Given below is the framework (Fig. 1) [4]

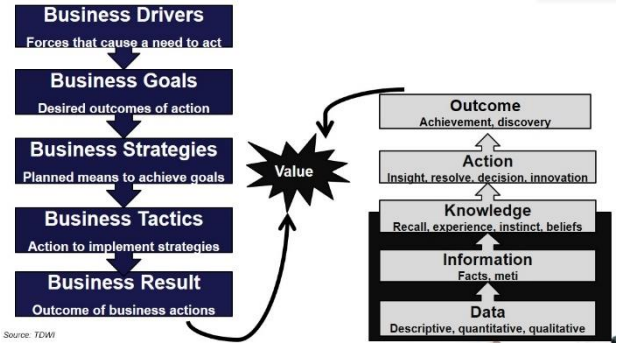

Fig 1. Business Intelligence Framework

The flow of business is shown on the left side of the framework. It starts with Business Drivers which cause a need for action. These could be external (market conditions, political/economical environment etc.) or internal (vision of the top management etc.). The Business Goals are set based on the drivers. These are the desired outcome of action. Business strategies (plans) are arrived at and Business Tactics (implementation of strategies) formulated. The operations yield the result.

Let us take an example from the airlines domain to illustrate the flow of business. An airlines is facing revenue loss (business driver) and wants to improve the situation. They set a target for their revenue growth in the next 6 months (business goal). They want to cut down the routes which are making losses and increase more flights in routes which are earning profits (business strategy). They get in to action and make the route changes, communicate the same to the public, make appropriate changes to their schedules, update their web portal, inform their agents and

so on (business tactics). After 6 months, their revenue figures are much better (business result).

Let us focus on the right side of the BI framework which gives the flow of data. It starts with data or measures. Information is derived out of the data. When the information is looked at for a period of time, it results in knowledge which leads to action. Action brings the outcome.

The data, information and/or knowledge is fed in to the strategy and tactics levels of the business flow. They help in strategizing and operationalizing. We will take the airlines example and illustrate this relationship between data and business.

The ticket booking data for all the routes for the last one year are collected together (data). The average percentage occupancy of the flights are calculates for each of the routes for every day (information). The daily average occupancy is looked at for the last one year to see the demand trend (knowledge). This is shared with the strategy and operations team who do the rescheduling of flights to optimize the occupancy (action). As a result of this, the revenue situation is much better (outcome).

Any business domain can be taken and the business flow/data flow drawn out in detail to chart the journey of data to decision.

In this framework, the data is stored in Online Transaction Processing (OLTP) systems. The OLTP data from multiple data sources are extracted, transformed and loaded in to a data warehouse. BI tools, reporting tools and data mining tools work on the data available in the data warehouse. This results in reports / dashboards which help the decision makers.

III. THE EVOLUTION OF ARTIFICIAL INTELLIGENCE (AI)

1950s witnessed the birth of Modern Artificial Intelligence when research pioneers started combining mathematics, information theory, and other areas to shape the new discipline. Since then, AI has seen many ups and downs, but the related theories, technologies, and methods have evolved continuously. Today, AI is experiencing a renaissance thanks to advances in technology, an increasing availability of data and computing power, and a myriad of use cases. [5]

The evolution of AI is depicted in the figure below (Fig. 2). [5]

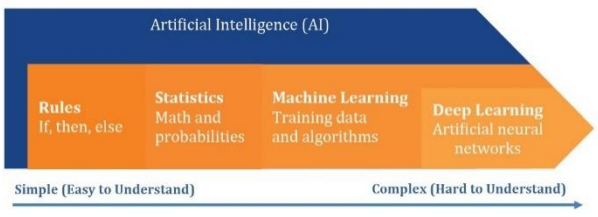

Fig 2. The Evolution of AI

The first AI systems were simple rule-based systems that used an if-then methodology to make decisions for predefined cases. For example, a bank loan expert system would look at the loan applicant's age, annual income, credit rating and other related parameters to decide on whether or not to approve the loan. A series of IF statements with predefined thresholds would form the backbone of the expert system.

However, it was quite a tedious task to build all the necessary rules, and Boolean logic cannot sufficiently represent complex scenarios usually. So, statistical methods came to be used to understand data sets and find patterns to develop more complex decision models. In the bank loan example, instead of making a decision on approving the loan, we would find out the likelihood of an applicant repaying the loan. Then, based on a fixed threshold (say, 80% likelihood), we may make the loan approval decision.

Machine Learning, which applies statistical methods to huge volumes of data, helps machines improve their learning capabilities. This approach does not require predefined rules, but rather uses training data to learn patterns that exist in real-world applications. [5]

In the bank loan example, instead of fixing thresholds on the likelihood of applicant repaying the loan, we would use the past loan data of the customers (who have repaid or defaulted) to learn the thresholds. As the amount of past data increases, the model becomes more accurate.

Deep learning is a subset of machine learning; it uses methods that mimic neural processing in the human brain. Deep learning uses artificial neural networks with multiple layers to recognize complex patterns hidden in large data sets. This approach requires sizable processing power and large volumes of training data. In the bank loan example, we could use deep learning to figure out the correlations between the various aspects of the applicants and their repayment likelihood.

Although AI is a novel area, it has already made its way into everyday life and business. For example, smart voice assistants use natural language processing to understand and communicate with users, AI-powered algorithms examine customer behavior and recommend relevant products, and video surveillance systems autonomously recognize faces and report suspicious behavior.

IV. THE ROLE OF HUMAN INTELLIGENCE IN BI

Fig. 3 below shows the spectrum of BI, from Data to Decisions, including the role of human intelligence.

In traditional BI, information and knowledge are derived from data and are presented as reports or dashboards or insights. Managers look at those and take business decisions. The extent to which analysis extends its support for the decision maker varies for different kinds of analysis.

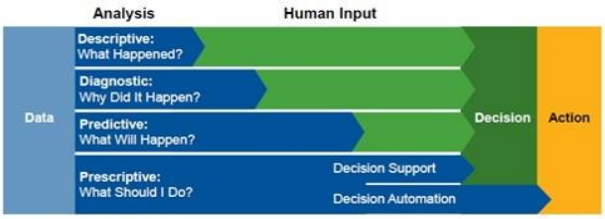

Fig 3. Role of Human Intelligence in BI

Descriptive analysis looks at data to describe what has happened. Sales transaction data from a retail store could be analyzed to provide the top 10 and bottom 10 products by revenue.

Diagnostic analysis goes one step further to find out the correlations among the data to figure out the root cause of business events. The fact of certain products appearing together most of the times in the top 10 or bottom 10 list might help the Manager to find out the root cause of some underlying business reality.

Predictive analysis does not stop with analyzing the past data but provides answers to questions related to future. Predictive Analysis talks about future with an acceptable level of reliability. It provides a few alternative scenarios along with the probability of their occurrence and assesses the risks involved. It is used to analyze current and historical data to understand customers, products, partners, sales etc and to identify potential risks and opportunities for a company. [5]

The answer to the question "What would be the top 10 and bottom 10 products in the next week?" might help the Manager to make purchase decisions for his retail store.

Prescriptive analysis enters into the domain of decision making by suggesting possible decision alternatives after analyzing past data. It examines data to find out what decisions should be made and which steps taken to reach an intended goal. Graph analysis, Optimization subject to constraints, complex event processing, neural networks, recommendation engines, heuristics and machine learning are some of the techniques used by Prescriptive analysis.

The retail store manager may provide the budget for the next week's procurement and past procurement patterns to the analytics engine which already has got the top 10 and bottom 10 list of products. Combining all that and following optimization subject to constraints, the engine may be able to provide the manager with the purchase decisions for the upcoming week. Here, analysis goes all the way up to making a decision, thus effectively replacing the human being at the decision making end. We arrive at a business decision based on AI techniques.

It is an appropriate time now to discuss the conceptual framework for AI in BI.

V. A CONCEPTUAL FRAMEWORK FOR AI IN BI

The BI framework discussed in the second section of this paper (Fig. 1) is extended to include the possible contributions of AI in BI. We know that BI is a journey from Data to Decisions. AI can contribute in the Data end (by making the unstructured data, so far not analyzed in BI) or in the Decisions end (by becoming more and more prescriptive in nature).

This is the conceptual framework for BI in BI shown in Fig. 4 below.

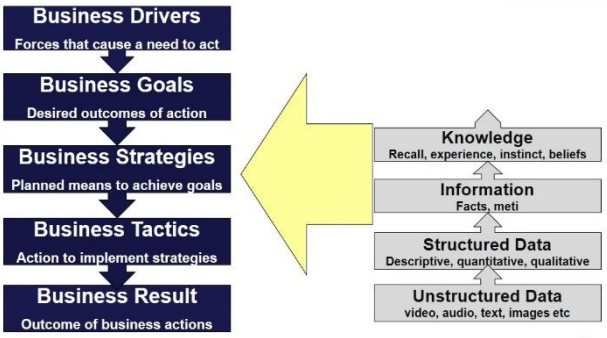

Fig 4. A Conceptual Framework for AI in BI

The flow of business depicted on the left side remains the same. However, the role of data is enhanced and is more valuable here.

First thing to note here is that, in traditional BI, the data that we keep referring to is structured data. The data follows a relational model and is stored in the data warehouse. However, unstructured data such as video, audio, images, social media content etc are not part of the traditional BI. That is because, it had been impossible to make sense of unstructured data and derive value out of it. With the evolution of AI, we see this barrier breaking.

Here, we include unstructured data too in the BI cycle. AI algorithms help to get structured data out of audio, video etc. For example, when a multinational company releases an electronic product, they might want to analyze the customer response to the product. In addition to the structured data in the form of customer feedback available from the company's website, more valuable data in the form of social media discussions on the new product might help in gauging the customer response. The tweets posted related to the new product may be taken for sentiment analysis and looked at from the dimensions of customer geography and demography. This will provide a much better picture of the customer response than the official structured feedback available from the company's web site.

Likewise, video clippings of customers moving around in a retail store might help in gauging the customer experience. This is more reliable than the formal feedback provided by the customers.

When it comes to decisions, we saw how in some cases, we are able to do prescriptive analysis. AI can help in including more and more business scenarios in the domain of prescriptive analysis. Machine learning and deep learning, with lots and lots of data (structured as well as unstructured) can help in coming up with better decision alternatives automatically.

AI can help in presenting the results of analysis in more innovative and natural ways. For example, Managers can 'ask' questions to AI systems and get answers and decision alternatives.

Thus, AI can help in enhancing Business Intelligence.

VI. CONCLUSION

We presented a coherent conceptual framework for incorporating AI in BI. AI helps to bring in unstructured data which has so far been neglected in analysis. AI also helps in getting in to the realm of decision making with prescriptive analysis. Any advances in AI or new tools in AI could be fit in to the appropriate place in this framework. So, it provides the BI professional with a kind of a plug-and-play model of AI enabled BI. A detailed look in to the available AI tools and technologies will help to populate the framework with instances of working implementations of BI. That would be my research interests.

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