JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Computational intelligence-based intelligent business intelligence system: concept and framework

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Abstract— *The main aim of this paper was to assess the concept and framework of Computational intelligence-based intelligence in business intelligence systems. Business Analytics (BA) and computational intelligence-based methodologies have had a profound impact on the success of corporations. This work paves the way for future research in these fields by highlighting important changes and new prospects. This study explores business intelligence systems development of computational intelligence solutions in-depth, which will be of interest to many researchers, professionals, and practitioners. They facilitate the elicitation of information, the management of knowledge, and the facilitation of decision-making so that properly informed and make accurate assessments even in contexts of high uncertainty. Recent technical developments have made use of computational intelligence to enhance intelligent business systems connected to, among other things, collective decision-making and social well-being; modeling; risk assessment; knowledge engineering; cybersecurity incidents detection; and knowledge extraction. Computational intelligence is mainly concerned with the processes that underlie ability and how to implement these mechanisms in machines. As AI makes its way into the corporate sector, computational intelligence focuses on the principles of business systems connected to manufacturing, entertainment, other industries, and medical and other fields such as marketing and engineering. Artificial intelligence may benefit greatly from the wealth of data that businesses now possess in data training, real-time data, and historical data [1]. Automated systems can promptly deal with complicated and perplexing situations, saving a great deal of time. Business intelligence systems bring together operational data and analytical tools in a single system to speed up and increase the quality of the decision-making process. Businesses utilize business intelligence systems to gather data, combine it and make it accessible for others to use. Business intelligence systems give actionable information at the appropriate time to the right people. This study proposes a framework for the application of computational intelligence in business systems today, using a variety of various methodologies.*

Keywords: *Computational intelligence, intelligent business intelligence system, cybersecurity, risk assessment, data mining, Swarm Intelligent Systems, EC framework*

I. INTRODUCTION

Businesses and organizations are faced with many questions and objectives. They collect the relevant data, analyze it, and choose which actions to take to achieve their objectives to conduct this research and measure progress toward these objectives. Analytical methods are included in business intelligence; however, they are only used in small amounts [1]. There are many benefits to using Business Intelligence (BI). Data scientists use advanced statistics and predictive analytics to uncover trends and anticipate future patterns [2]. The classic business intelligence paradigm has been the foundation of business intelligence solutions for a long time. The top-down approach to business intelligence, in which the IT organization was in charge, and static reports were used to answer most analytical inquiries. Those who wanted to ask more questions regarding the report they got had to wait until the end of the line, which meant they would have to start from scratch [2]. People could not make choices based on current facts due to delayed, irritating reporting processes. When it comes to routine reporting and responding to static questions, the traditional approach to business intelligence is still the most frequent.

In contrast, current business intelligence is user-friendly and engaging. IT departments still play an essential role in monitoring access to data, but many different levels of users may quickly customize dashboards and produce reports. Users may take control of their data visualization and analysis by using the right software [2,3]. Businesses are increasingly adopting a self-service approach to data collection and analysis in the current business intelligence paradigm. Users may view and interact with their data directly since IT maintains the data (security, accuracy, and access). Many self-service BI tools and platforms make it easier to do analysis. Because of this, users with little or no technological expertise may more easily view and comprehend their data. Ad-hoc analysis, visualization techniques, and the creation of customized widgets for a variety of user levels are all possible with a variety of BI systems.

Data handling techniques that are computationally clever are critical in various fields where quick and automated decision-making is required. Increasing amounts of data are being collected and used by businesses, which is helping to improve decision-making in the field of business intelligence and the conduct of day-to-day operations [3]. Corporations may now use machine learning systems to determine new patterns and insights in massive amounts of data and make quick conclusions about how to present them.

Automated systems can promptly deal with complicated and perplexing situations, saving a great deal of time. There are various data sources that business managers may use to make key decisions, including supply chain management, and customer relations. As a result, various business intelligence (BI) solutions have been created to assist in decision-making. Data analysis and visualization capabilities are missing in certain current BI solutions. This study proposes a framework for the application of computational intelligence in business systems today using a variety of various methodologies. Computational intelligence concepts and frameworks covered in this article include Swarm intelligence, which may even outperform human intelligence and can significantly benefit the business sector. This aids in the development of structures and techniques that have assisted the business systems in getting the best outcomes possible.

II. RESEARCH PROBLEM

The main problem that this paper will address is to review how computational intelligence concepts and framework ca be applied in addressing challenges in business intelligent systems. Organizations' endeavors to communicate and exchange data will expand as they try to be more data-driven. Collaboration between departments of an organization will need data visualization. Computational intelligence and machine learning automate and simplify complicated activities in advanced BI and analytics systems. Enterprises will be able to examine their data and acquire insights at a deeper level thanks to these capabilities. They continue to learn from the natural world as technology expands into every aspect of our lives and becomes ever more prevalent. As a result, it has the potential to revolutionize several technical domains, from artificial intelligence to robotics. Swarm intelligence is one such example.

III. LITERATURE REVIEW

i. *Computational intelligence concepts and Frameworks*

a. *Swarm Intelligent Systems*

[5] asserts that swarm intelligence (SI) is the group pattern of behavior of decentralized natural or artificial systems. Swarm intelligence (SI) is a bio-inspired computing approach created by analyzing the collective behavior of swarms in nature via the intricate interaction of individuals without monitoring. Swarm intelligence (SI) may be generated by the collective action of artificial entities, like foraging robots. These basic agents communicate with each other and their surroundings in a limited context, according to [5.] It's fairly uncommon to draw inspiration from nature, particularly biological systems. Rules are basic, but encounters between such entities result in "intelligent" global behavior that any individual agent does not understand. Despite this, no centralized control structure mandating how interested parties should operate. An ant colony, birds flocking, mammal herding, and bacterial development are all instances of SI. SI research began in the late 1980s [6].[7]. SI can solve traditional optimization problems but can also be used to get library materials, communicate, classify medical datasets, plan heating systems, track moving objects, and make predictions. SI can be used in various fields, including fundamental research, engineering, business, and the social sciences.

Like the EC framework, SI is a highly popular and important solution for optimization challenges; the techniques based on SI are particularly flexible and efficient in handling complicated problems that traditional approaches cannot solve [6]. The fundamental distinction between EC and SI techniques is that in the process of searching across generations, a fixed-size population of people is utilized, and in each generation, the discoveries of individuals are reviewed to alter the search strategy in the following generation; this is the most significant difference between EC and SI methods.

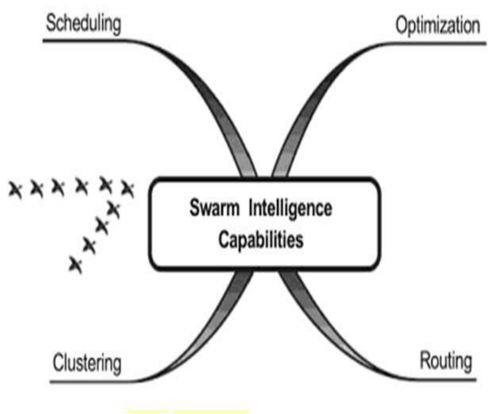

Figure i: Swarm intelligence's capabilities [7]

SI approaches emphasize self-organization tactics and the ability of each person to work on their own to solve challenges. Self-organizing strategies create a system of people that individually respond to local stimuli and cooperate in carrying out a global task [7]. These tools mimic the behavior of natural insect or animal colonies.

b. Swarm Technologies

Ant System:

Stigmergy, a phenomenon associated with blind ant pheromone transmission, served as inspiration for this project. Stigmergy is the term for this phenomenon. In addition to pheromone intensity, the ant's likelihood of following that route is influenced by its proximity to that city, known as visiblity[8].

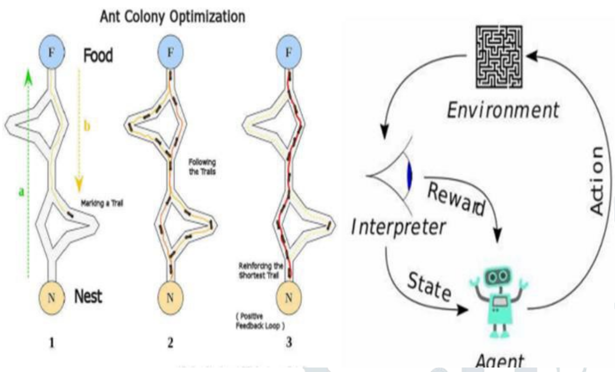

Fig ii: Ant colony optimization [8]

Strategy: The strategy aims to use historic (i.e., phenomenon-based and heuristic) knowledge to build optimization algorithms in a probabilistic step-wise way and then incorporate the information learned from building solutions into the construction history. For each component, the likelihood that it will select is decided by the heuristic contributions of that component to the total cost of the solution [8].[7] ,

The Bees Algorithm:

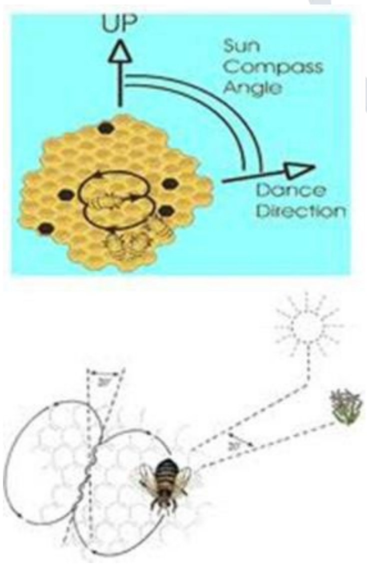

Fig iii: Bees algorithm [8]

Honey bee foraging behavior serves as an inspiration for this design. The scout bees return to the hive and perform a waggle dance to inform the other bees about the food source's quality, quantity, distance, and direction [8]. The algorithm aims to find and explore excellent sites in a troublesome search area. Every new version of the search engine uses a swarm of scout bees to scour the area for new good sites to use in the search results.

Intelligent Water Drops:

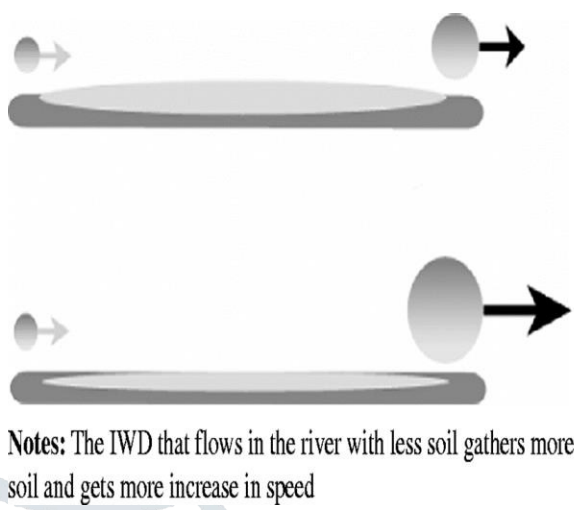

Fig iv: Intelligent water drops optimization [8]

An intelligent water drops algorithm (IWD) is inspired by real rivers and how they discover virtually ideal courses to their destinations. When water droplets interact with one another and with their riverbeds, they produce near-optimal or ideal paths [8]. Water droplets have three key features that make this possible. These systems collect material from the riverbed at fast speeds, enabling them to carry more soil. These first droplets of water clear a road for the rest. Another difference between low-soil and high-soil pathways is the increased velocity of water droplets. A water drop will choose the route with the least amount of dirt when it needs to decide. The best route is shown as the one with the lowest dirt on its connections when many fake water drops work together to transform their surroundings. The IWD algorithm creates the answers one step at a time.

ii. Related studies

The Wyss Institute at Harvard University [9] has completed an experiment that demonstrates the tremendous potential of swarm intelligence in robots. Use cases that combine self-driving robots for search-and-rescue operations, construction, environmental concerns, and medicinal applications are all part of the project. The Wyss Institute produced "Kilobots," low-cost mobile robots that use a unique visual system to coordinate movements like a school of fish[9].[10–12] Kilobots are built on algorithms designed to give a platform for evaluating future swarm behaviors and are intended to be simple to use in creating robot swarms. One thousand Kilobots self-assemble in the connection to demonstrate "foraging and firefly inspired synchronization" in a complex swarm behavior.

Before recently, the discipline of robotics was primarily concerned with producing autonomous intelligent robots[10]. As more algorithms of swarm intelligence tackle some of our most difficult issues with their unique dynamic, self-sustaining capacities and collective behaviors, this is rapidly changing. As private 5G networks become more widespread, robots will be able to operate together and contribute to the explosion of swarms. We can only fathom how far-reaching the advantages of these use cases will be when they are implemented in the real world. It will be when the "larger global behavior" comes through swarm intelligence algorithms that are simple to use and accessible.

iii. Applications of Swarm Intelligence in Business

When it comes to Artificial Intelligence (AI), Swarm Systems utilize algorithms to maximize the overall performance of the group or system in real-time. Swarm intelligence may be seen in the famous Waze road-navigation program, which employs crowdsourcing to produce and update its maps. It started by modifying its digital maps based on its users' GPS data and by allowing registered users to make their improvements to the maps. This technology has been used to map whole cities, such as San José, Costa Rica's capital. Similarly, Waze users give real information from accident sites and traffic jams [11] exactly as ants do. Everything from the result of the Super Bowl to fashion trends to important political events can now be predicted using Swarm Intelligence (SI). Investors and merchants alike may benefit from swarm intelligence's improved ability to foresee market fluctuations. Swarm intelligence has been around for a while, but the rise of edge computing has given it a fresh lease of life. Instead of relying on massive data centers or the cloud, this technology allows for more processing and storage to be done locally [11]. As a result of improvements in IoT, machine learning, and 5G, swarm systems are now more responsive and effective than ever before.

Swarm intelligence will benefit organizations as the world becomes more volatile, large, and complex: identifying new sources of growth and predicting and managing upheaval.

iv. Case studies on the Use of Swarm intelligence in business

Case study 1

London's Gatwick Airport, one of the world's busiest, serves as an example. The airport's administration used Swarm intelligence to increase efficiency in the face of increasing airport demand and capacity restrictions according to Gatwick's head of IT commercial and innovation [11,12]. Gatwick used to rely on "rule of thumb" flight estimations to determine departure timings, but this has been replaced with a more accurate system. Local conditions often showed these assumptions incorrect, such as minor weather changes or human resources shortages. Using a swarm-based approach called FlightID, the Gatwick team collaborated with ConvergentAI to gather all available data on the many variables influencing flight departure timings. The CEO of ConvergentAI, Tom Brock, refers to this technology as "decentralized small data" analytics [12]. As opposed to the average flight delay at the airport, swarm algorithms learn about each aircraft's performance down to the most minute details of how a given airline performs on wet days. If flying on an aircraft with many people, for example, the journey will likely take longer. It is different to fly at 6 a.m. vs. at 8 a.m. Business travelers vary from those traveling with their families when it comes to conducting. Gatwick was able to better predict and react to the effects of ever-changing circumstances because of this nuanced but more holistic picture. Consequently, 1.5 million more passengers were able to leave on time in 2018.

Case study 2

Southwest Airlines was encountering problems with its cargo handling a little over a year ago. There was not enough capacity to handle the planned freight loads at several airports, which resulted in bottlenecks in Southwest's cargo routing and handling system[13]. There was apparent rationality to loading cargo aboard the first aircraft heading on the appropriate route at that moment. However, as a result, employees were forced to spend extra time transferring goods and occasionally loading planes pointlessly.

Southwest found a solution in an odd place: ants. In particular, scientists studied how ants hunt for food by following basic principles and always arriving at the most effective path. When they applied their study to Southwest's situation, they found something surprising: it might be preferable to leave goods on an aircraft originally flying in the incorrect direction. A package sent from Chicago to Boston may be more cost-effectively left on an aircraft bound for Atlanta and then Boston rather than removed and re-boarded on the following flight [13].

Using this insight in the busiest cargo facilities has cut freight transfer rates by up to 80%, decreased the burden of workers who move goods by up to 20%, and reduced nighttime transfers significantly [13]. As a result, Southwest Airlines has reduced the size of its cargo storage facilities and reduced labor expenditures. As a result, the corporation can take advantage of new business prospects since fewer aircraft are now flying full. Southwest expects to make over $10 million in yearly revenue due to the upgrades. Numerous corporations have benefited from similar studies into social insects' behavior by developing more effective methods to schedule production equipment, distribute jobs among employees, manage personnel, and devise strategies [13].

IV. ITS FUTURE

Computational intelligence in business intelligent systems will transform how the corporate environment conducts its business in the United States. Rather than relying on a single intelligent entity soon, researchers expect cooperative swarms to emerge as technology improves. As swarm intelligence concepts become more widely used, it has the potential to revolutionize a variety of businesses and aspects of people's lives, both at work and otherwise. Amidst concerns about giving robots too much power, the advantages of swarm intelligence are undeniable [14]. Consider the insurance industry. Inspections conducted by Swarm Drone alone are predicted to increase the efficiency of the claims process by enabling efficient investigations and settlements of damages with minimum human interaction - a feature particularly important when an area is considered unsafe. Work is now ongoing to gather IoT (Internet of Things) swarm endpoint data, which will provide even more information about risk and greater insight and foresight in the telematics context. This information aids decisions about everything from marketing success to company finances.

V. ECONOMIC BENEFITS

Swarm intelligence's advantages for the American economy are growing. Several prominent businesses are involved in the Swarm Intelligence industry, which is relatively competitive. Some companies now have a disproportionate amount of the market share. As behavioral intelligence improves, new firms gain market share and extend their reach into developing countries. The increasing need for automation and route analytics in the retail e-commerce industry is likely to boost the market throughout the forecast period[16] because of the automation in the retail e-commerce sector. The rising use of swarm-based drones by the military and defense agencies in the United States is one of the main reasons for expanding swarm intelligence in North America.

It also helps to discover significant areas of early detection and diagnosis and therapy as well as result prediction and prognosis assessment in the North American region via the use of the swarm intelligence system and AI integration. In addition to artificial intelligence and blockchain, swarm robotics is also gaining traction. Georgia Robotics and Intelligent Systems Lab (GRITS) researchers have created a tiny swarm of robots that can execute basic tasks like spelling and playing the piano, inspired by natural swarm intelligence. For this reason, the robots depend on information from other robots to help them plan their path. The Swarm Intelligence Market is estimated to grow at a CAGR of over 37% during the projected period. (2021 - 2026). The market is driven by the merging of biological behavior with artificial intelligence [18].

Operational expenses and travel time are increased when products and logistics are transported through alternative routes for commercial purposes. Consequently, the need for Swarm Intelligence will rise during the projected period as analytical models that can be solved using the Swarm model are required. Swarm intelligence platforms are projected to increase demand as the adoption of the cooperative Multi-Agent System (MAS) in the healthcare sector is driven by real-time closed-loop intelligence controlled by SI algorithms [18,19]. Human swarms have converged online due to the rising tendency to anticipate sports and financial trends and the efficacy of commercials and movie trailers using interfaces and AI algorithms.

The collective action of many independent entities results in what seems to be intelligent behavior. Collective behavior of self-organized, decentralized natural or artificial systems mainly deals with the collective behaviors emerging from local interactions between people and their surroundings [19].

VI. CONCLUSION

Every year, we identify current trends in business intelligence to keep users abreast of new developments as company demands and technology evolve. The plow invention didn't eliminate the need for farmworkers, and the invention of the computer didn't eliminate the need for mathematicians. The advent of computational intelligence, like all technological revolutions, will be used to assist humanity in reaching a new paradigm rather than replace it entirely.

It turns out that a lot. Solitary social insects have little intelligence, and their activity together is mostly self-directed with little oversight. It is possible to discover extremely efficient solutions together, and they can cope with a wide range of changes in the environment automatically. These models have been constructed over the last 20 years, and they are now being used in the commercial world by the authors and other academics, who have named this phenomenon "swarm intelligence." Several companies have already benefited from their research in developing more efficient methods for scheduling factory equipment, dividing tasks among workers, organizing people, and even plotting strategic goals. For example, software tools developed by Hewlett-Packard researchers mimic how ants locate the quickest path toward new food sources. This process has led to a better understanding of how phone traffic is routed through the network.

Similarly, Southwest Airlines has utilized a similar methodology to route freight more effectively. Honeybees seem to follow a simple but effective rule for allocating labor: they tend to specialize in a single activity unless they feel an essential requirement to execute a different function. As a result of their work, Northwestern University researchers have developed a painting system for trucks capable of adapting to changing circumstances automatically. According to the authors, swarm intelligence might one day be used to organize a company's whole operations. They believe that a self-organizing enterprise that could respond quickly and instinctively to rapidly changing markets would be the ultimate result.

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