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Article

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Soft Computing: Goals, importance, and various Problem-Solving techniques

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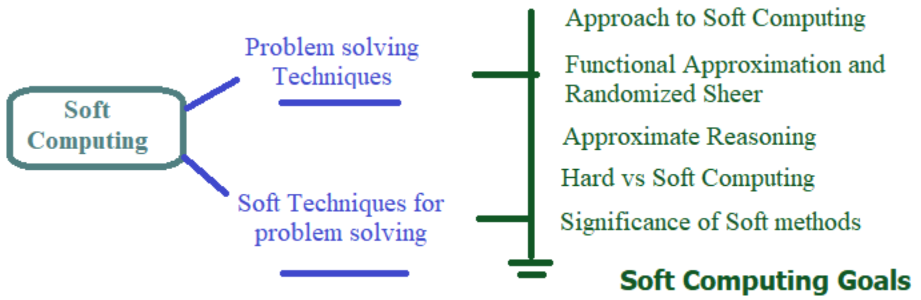
ABSTRACT

The purpose, importance, approach, qualities, and requirement of soft computing are all discussed in this study. Apart from that, the paper describes the work of numerous writers in soft computing and various problem-solving techniques such as genetic algorithms, fuzzy logic, and machine learning. The report also discusses the differences between hard and soft computing. Furthermore, the study discusses various problem-solving techniques' benefits, limitations, and drawbacks. In soft computing, on the other hand, approximation models are utilized instead of traditional computation to handle complicated real-world problems. Soft computing can also be fraught with uncertainty and ambiguity. Soft computing is a form of computing that includes fuzzy logic, genetic algorithms, artificial neural networks, machine learning, and expert systems. It has become a significant part of the work in automatic control. Soft computing technologies are now widely employed in various residential, corporate, and industrial applications and have proven effective. Soft computing approaches and applications will become more prevalent as low-cost, high-performance digital processors and cheap memory chips become increasingly popular.



Keywords: Soft Computing, Fuzzy Logic, Genetic Algorithm, Machine Learning, Artificial Intelligence

INTRODUCTION

Soft computing uses approximation computations to get imperfect but usable answers to complex computer problems, like how to solve a complex equation. Some issues can't be solved or take too long on current hardware. This method can solve these types of problems.[1]

Soft computing is a way to solve problems that don't use machines, like a person. Because soft computing uses the human mind as a model, it doesn't care if some things aren't 100% true, ambiguous, unclear, or approximated.[2] People who study soft computing can do something a traditional computer can't do, like solve problems that a computer can't. Figure 1 shows smooth computing characteristics. Since its inception in the 1980s, many people have researched and studied soft computing.

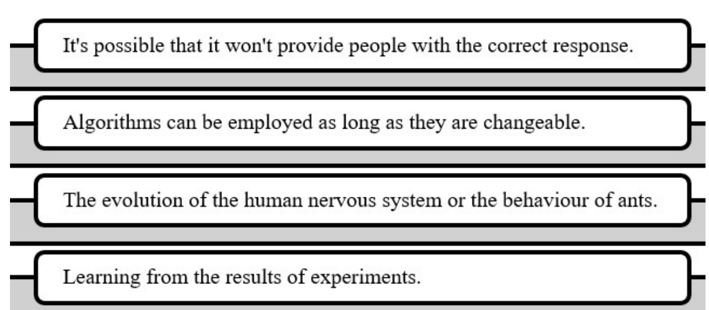


Figure:1 Characteristics of soft computing

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It has been studied as a math and computer science branch since the 1990s. Inspiration came from the human mind's ability to look at real-world solutions to problems and copy them. Possible is used when there is insufficient information to solve a problem.[3] Soft computing is used when there is inadequate information to solve a problem. Soft computing is used when math and computer processes can't solve a problem that isn't clear enough. Soft computing has a lot of practical applications at home, in business, and the world of work. Figure 2 shows the need for quiet computing.

The opposite of soft computing is complex computing, also known as "traditional" computing. This term alludes to a group of computational procedures that combine elements of AI with those of NS (AI). It provides low-cost options for solving complex real-world problems for which no state-of-the-art computational answer is available. Zadeh used the phrase "soft computing" to describe a new way of thinking about computers in 1992. The supply of approximate yet rapid answers to complex real-world problems is a crucial goal of soft computing.[4] The applications for soft computing are vast.

- Soft computing yields approximate but reliable results in the face of uncertainty.
- Soft computing techniques are flexible enough to keep the system running well despite unexpected changes in the surrounding environment.
- Through trial and error, knowledge is gained in soft computing. As a result, in many cases, soft computing can solve a problem without needing a mathematical model.
- It uses machine learning, fuzzy sets, genetic algorithms, artificial neural networks, and expert systems as its foundation.

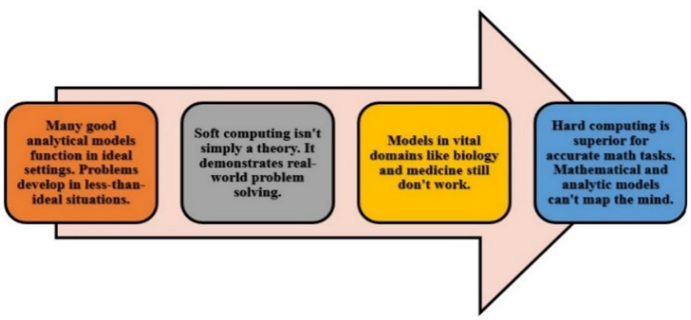

Figure 2. Need for Soft Computing

People who study soft computing say it combines fuzzy logic, neural computing, evolutionary and genetic computing, and probabilistic computing into a single system that people from many fields can use.[5] These methods are called soft computing. So-called soft computing tries to make decisions like humans do by considering our tolerance for imperfection and uncertainty and approximate reasoning and partial truth.

Goals of Soft Computing

Soft computing is a new, multidisciplinary field that aims to build a new kind of artificial intelligence (AI) or computational intelligence. The main goal of Soft Computing is to build intelligent machines that can solve real-world problems that can't be modeled analytically or are too complicated to show. Its purpose is to take advantage of people's willingness to let things happen.[6]

- Approximation: the model's features are close to, but not the same as, those of the real thing.
- Uncertainty: researchers aren't sure if the model's characteristics match the real thing.

Imprecision and incomplete truth were used to get as close as possible to how humans make decisions, so this is how it worked: Because the model isn't exactly like the real thing, it doesn't have the same characteristics as the real thing, but they're very close.[7]

Importance of Soft Computing

Soft computing is not the same as complex computing. Soft computing allows uncertainty, ambiguity, partial truth, and approximation. On the other hand, complex computing does not.[8] Soft computing's primary goal is to use this tolerance to achieve tractability, robustness, and cheap solution costs, all of which can be accomplished at a low price. The human mind is used as a paradigm for "soft computing." Figure 3 shows four fields that constitute soft computing.

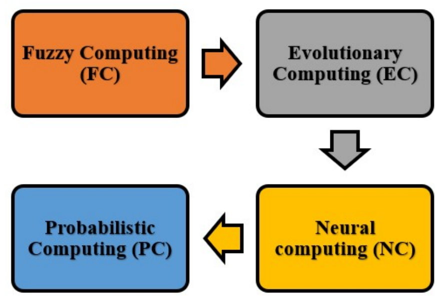

Figure 3. Four fields that constitute Soft Computing

- Soft computing is a mix of techniques that work together somehow, with each partner bringing a unique way to solve problems in their field.
- In general, soft computing's main methods aren't competing.
- Soft computing could be seen as a foundation for the new field of Conceptual Intelligence, which is still in its early stages. Figure:4 shows mild computing properties.
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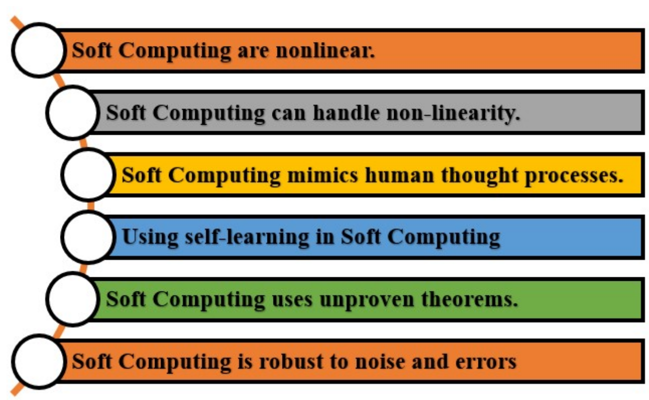

Figure 4. Properties of Soft Computing

Why Soft computing Approach?

A mathematical model and analysis can be performed for relatively simple systems. More complicated systems develop in biology, medicine,[9] and management systems, and traditional mathematical and analytical tools cannot solve them.[10] Humans can typically, as to be shown in figure 5.

Figure 5. Soft computing Approach

LITERATURE REVIEW

In 1981, Lotfi A. Zadeh wrote "What is Soft Computing," his first paper on soft data analysis. This paper led to the idea of "soft computing." Springer-Verlag published it in 1997 in Berlin and New York, and it was perfect.[11]

According to Zhang Wengang et al.[12] machine learning and evolutionary computation are two research areas. It started in the 1990s. When data is scant, be creative and use what little you have. SC is employed when computers and math are useless. It has a wide range of possible applications, including the workplace, the home, and the industrial. Amiri-Ramsheh Behnam et al.[13] report that solid scales reduce oil production. Wax serves as a sealant in oil pipes. When temperatures are low, flow rates are drastically altered. In other words, the wax disappearance temperature is the temperature at which wax deposits dissolve and lose their effects. Attanayake AM et al.[14] argue that expressing a point as an interval is a helpful way to recognize dynamic uncertainty and make better decisions. Dengue prevention measures are set relative to the size of the gap. There are various approaches to dealing with variables that depend on or are independent of an interval. Since the 1970s, Johnson C. Agbasi et al.[15] have found that simulating and modeling water quality parameters is an effective tool for water resource monitoring and assessment. Results are more trustworthy and reliable when many modeling approaches are used. The current investigation employs the Levenberg-Marquardt algorithm to examine a ferrofluid flow model with a magnetic dipole, as described by Shoaib, Muhammad, et al.[16] From a system of partial differential equations, non-linear ordinary differential equations can be derived. Başakn, Eyyup Ensar, et al.[17] report using various statistical techniques, including hybrid models, artificial neural networks, Gaussian Process Regression, Support Vector Machines, and Multivariate Adaptive Regression Splines. Autocorrelation functions are used to determine the optimal mother wavelet and decomposition levels. According to Sangram Ray et al.[18] the conventional method of researching water quality indicators (WQIs) is time-consuming and unreliable.

AI models are being used to capture non-linear and complicated processes. Multiple model variants utilizing high gradient boosting and neuro-sensitivity analysis were developed for feature extraction. Sangram Ray et al. reported the widespread use of large-scale sensor networks.[19] The number of sensors and other devices that can be connected to the internet has been explored.[20] Power outages and computer resources are both at critical lows. Analytical tools are fed data. The information gathered through these networks piques the interest of many people. Researching droughts is crucial for developing reliable drought prediction models, as stated by Biswajeet Pradhan et al.[21] Drought forecasting is challenging because of the consequences of complex hydro-meteorological interactions and climate change. Drought predictions from artificial neural networks are 100% accurate. Some essential criteria for reliability analysis are the rise and fall times, the duration, and the energy integral of short-term waveforms, as stated by Li, Kejie et al.[22] However, analyzing them for the electronics above may be difficult due to a lack of samples and testing. Soft computing has proven helpful in many contexts.[23–25] A few illustrations are provided below.

- This strategy is frequently employed in games like poker and checkers on appliances for the kitchen, such as the rice cooker and the microwave.
- The top four most utilized home appliances are washing machines, stoves, refrigerators, and air conditioners.
- Further, it has applications in robotics and other fields.
- Image processing and data compression are only two of soft computing's many applications.
- It was used to denote who wrote a particular piece of text.

Traditional computational or analytical models do not necessarily lend themselves well to solving real-world situations.[26,27] Consequently, researchers require a supplementary technique, such as soft computing, to obtain a reasonably accurate answer estimate.[28,29]

- Complex mathematical problems are quickly and accurately solved by high-powered computers - inadequately considered problems with practical answers.
- Mathematical problems of this type can be solved using analytical models that hold under ideal conditions. But even in a perfect society, problems in the real world will always be there.
- Insights into theoretical and practical problems can be gained using soft computing.
- Soft computing approaches like those used to build a mental map are more realistic and valuable than theoretical alternatives like mathematical or analytical models. Given the discussion up to this point, this conclusion seems to sense.

VARIOUS PROBLEM-SOLVING TECHNIQUES

There is no way for a computer to solve a problem independently, so it needs help.[30] When it's all said and done, the computer doesn't have to solve any issues. In this case, the programmer ensures that the computer can understand and follow the answer to the question. Although conceptual intelligence is a relatively new topic, soft computing will play a significant part in its evolution. The branches of soft computing include fuzzy logic (FL), machine learning (ML), neural networks (NN), probabilistic reasoning (PR), and evolutionary computation (EC). Soft computing, meanwhile, employs analogous methods to address any issue. Many steps or stages need to be done first to solve a computer problem.[31] How to deal with problems is shown in figure 6.

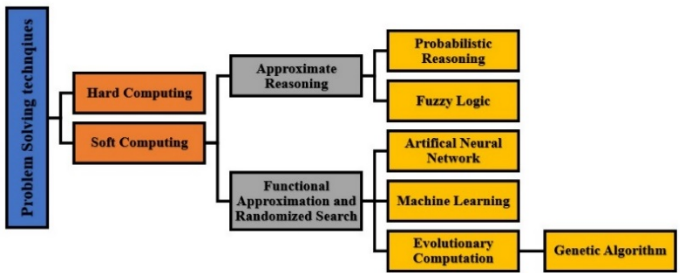

Figure 6. Problem Solving Techniques

Hard Computing

Long before the invention of the computer, there was a method of computing known as complex computing. It is necessary to use an analytical model that is extremely precise.[2] Using a mathematical model or algorithmic rule in a complex computing method produces a warranted, agreed-upon, and correct result that can be used to decide what managers should do in their respective situations. In this instance, binary and obvious logic is employed. It cannot function without a consistent input file. An answer to a real-world problem cannot be discovered through complex computing.[32]

Soft Computing

Soft computing is a computer model that solves non-linear problems with uncertain, imprecise, and approximate solutions. There are problems with this. It was made to solve them. Think of these problems as real-life ones that need human-like intelligence.[33]

Complex computing uses conventional mathematical methods to get solutions.[34] It provides an easy and obvious answer to the problem. All numerical problems are examples of complex computing. On the other hand, soft computing takes a different approach than a traditional computer. It is now possible for academics to quickly and readily find answers to some of the world's most pressing problems using soft computing.[35] Soft computing outcomes are not precisely computed or supplied either.

Description of Problem-Solving Techniques of Soft Computing

Soft computing is different from traditional computing because it works with approximation models and solves complex, real-world problems that are not easy to solve.[36] Because soft computing doesn't care about exactness or uncertainty, partial truths or approximations, it doesn't care about them. The human brain shows how soft computing should be done. Soft computing techniques include fuzzy logic, genetic algorithms, artificial neural networks, machine learning, and expert systems. There are a lot of different types of soft computing techniques. These days, soft computing techniques are used in a wide range of applications at home, in the office, and the world of work.[37]

Functional Approximation and randomized Sear

Approximation problems generally ask us to choose a function from a well-defined class that almost fits a target function. Many applied math fields, like computer science, use function approximations to determine how bacteria grow in microbiology.[38] When there aren't any theoretical models, or it's hard to figure out how to do them, function approximations are used to figure out how to do them.

Machine Learning

Algorithms that learn are algorithms that can learn from experience and data. Intuitive machine learning algorithms make predictions or decisions.[39] They build a model from data. Because creating machine learning algorithms is difficult or impossible, they are commonly used. They are used in medical imaging, email filtering, and voice recognition. Statistical computing is a subset of computational statistics. Instruments, theories, and applications help machine learning. Data mining is a research method that focuses on learning without being instructed. Some machine learning implementations use data and neural networks to replicate brain activity. When used to address business problems, it is termed predictive analytics.

Overview of Machine Learning

People that employ learning algorithms believe that previous approaches, algorithms, and conclusions will work again. They don't need to be instructed how. Computers use data to learn how to do things better. Let the computer figure out independently rather than having people explain each step. Computers can be taught to solve issues without a complete solution. That's "machine learning." When there are numerous possible responses, labeling them makes them valid. Even better, the computer may utilize this data to refine its algorithms for determining accurate answers. These handwritten numbers have been used to teach computers to understand digital text.

History of Machine Learning

A worker at IBM used the term machine learning in 1959. Arthur Samuel was one of the first to create computer games and AI. During this time, self-teaching computers learned about the world. In the 1960s, one of the most important papers on pattern categorization was published. Learning Machines by Nilsson was significant work at the time. Until the 1970s, people were interested in patterns. A series of guidelines can be used to learn to recognize 40 characters from a computer keyboard. Modern machine learning has two primary goals: classifying data using built-in models and predicting what will happen next. Computer vision of moles and supervised learning could help a hypothetical computer program learn to group data.

Artificial Neural network

Computers that look like animal brains are called brain computers. Computer systems look like artificial neural networks (ANNs), or neural networks (NN) look like animal brains. ANNs and NNs are also called neural networks. When they connect in an ANN, artificial neurons' units or nodes look like neurons in a real brain. Each link can send a signal to other neurons in the same way. Sending signals to other neurons is what an artificial neuron does when it gets a signal. It analyses the signal and then sends signals to the other neurons connected to it. A non-linear function is used to make each neuron's output different. Edges are where two things meet, and the weight of neurons and edges changes significantly, making them more or less dense. A wire's weight can make or break a signal's strength at a connection. Neurons may have a threshold that lets them send a signal only if the total signal is above this threshold, which would let them send a signal. A layer is where many neurons are put together into one big group. Separate layers may change their inputs in different ways. It can often happen for signals to move back and forth between layers, called crossing.

Artificial neural networks (ANN) are computer simulations of human brains developed by scientists (means a machine that can think like a human mind). When it comes to learning and memory, computers and other devices can function similarly to the human brain. Traditional programming techniques are used to construct ANNs structurally similar to human brains. Just like the nervous system, it plays a crucial role in maintaining health.

History

The artificial neural network was created in 1943. Brain-based learning theory was proposed in the 1940s by D. O. Hebb. "Farley and Wesley A. Clark in 1954 created human learning". The perceptron was invented in 1958 by the US Navy. Theoretically, an entire circuit cannot be processed by basic perceptrons and, thus, computers. John used backpropagation to change controller parameters in 1973. In 1986, backpropagation learned interesting internal representations of words as feature vectors. This method of 3D object recognition was introduced in 1992. Then came "deep learning" networks for visual recognition.[40] In 2009, ANNs won image recognition contests.

Evolutionary Computation (EC)

Real real-world growth affects algorithms that seek the optimal method to do things. First, a team will work together to tackle this issue. A feature assesses a person's health. People impacted by natural evolution should use convergence in their actions. A new group of fitter people is formed. Some people are removed to keep the population level with the rest of the globe. Repeat until goals are achieved. EC is a sub-field of soft computing and AI.

In evolutionary computation (EC), new algorithms evolve with data and experience. Nature's algorithms are based on changes over time. It generates a list of potential solutions to a problem and then refines it to select the best. Many other people, besides swarm intelligence, use these methods.[41] It employs optimization to improve solution generation - a solution's performance in a particular setting. EC is a method. Evolutionary algorithms study nature to enhance and speed up processes.

Genetic algorithms

Natural objects have always been and continue to be a great source of inspiration for people everywhere. Search-based algorithms employ natural selection and genetic principles to help people locate what people want. GAs is a subset of Evolutionary Computation, with many more uses.[42] GAs have various advantages, making them immensely popular, as shown in figure:7. The genetic algorithm draws almost entirely on natural selection and evolution concepts.[43] Because there is no equivalent to search-based algorithms in genetics or natural selection, the term "genetic algorithm" is a misnomer.

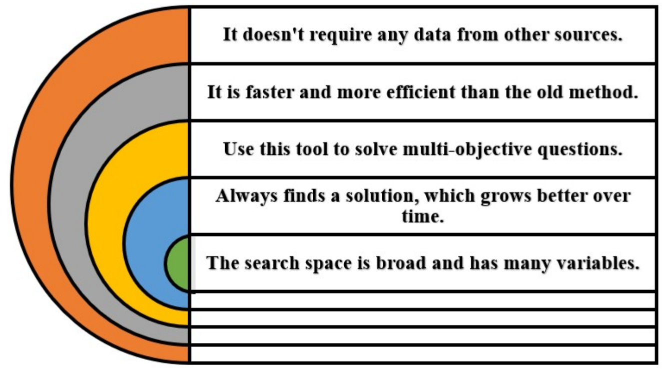

Figure 7. Advantages of Genetic Algorithm

There are several approaches to fixing an issue with GAs. Natural genetics recombined and altered these solutions, resulting in new offspring and grandkids.[44]

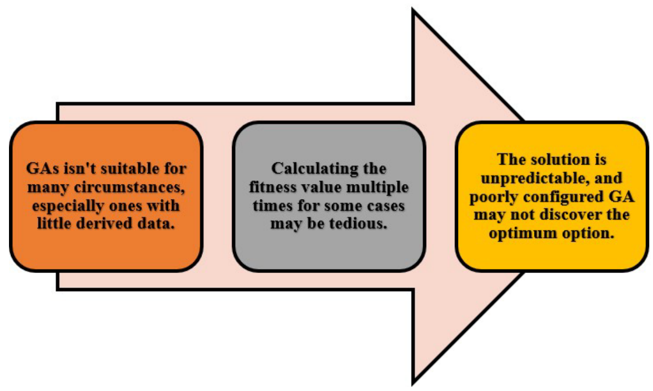

Figure 8. Limitations of Genetic Algorithm

- Evolutionary algorithms (EA) were designed to resemble natural processes like evolution.
- Better functioning structures are more likely to be chromosomally recorded. Repetitive success increases repeatability.
- The algorithms employ basic encoding and replication techniques to illustrate complicated behavior and solve complex tasks.
- Genetic algorithms (GAs) are reliable and adaptable tools for tackling search and optimization issues. They are based on the theory of natural evolution.
- GA achieves this by simulating how organisms evolve. Like any technique, GAs also suffers from a few limitations. These include as shown in figure:8.

Approximate Reasoning

Giving up soundness or completeness in exchange for a significant speed-up in reasoning is what it's all about. Do this so that the speed gain is at least as significant as the number of mistakes users make.[45] Keep an eye out for the proper application domains and the quality of the approximate reasoning methods that come out of these approaches.

Fuzzy Logic

Fuzzy logic, as used above, is a branch of mathematics concerned with attempting to solve problems with only partial or absent knowledge.[46] Find a massive set of valid inferences considerably more quickly. Fuzzy logic is a method of problem-solving that considers a wide range of criteria to arrive at a reasonable answer. Fuzzy logic is widely believed to be a practical problem solver.[47]

Fuzzy means something that isn't clear or clear. Researchers can't always tell if something is accurate or inaccurate in the real world. Fuzzy logic is fundamental because it gives us a lot of flexibility when people have to choose. Using this method, people can think about any situation's inaccuracies and uncertainty.[48,49]

One is the truth value, and zero is the actual value that is never true. Consequently, there is no way to tell whether something is true or not accurate in a fuzzy setup.[50]

- In reality, getting the truth isn't always easy.
- When scientists say it's warm today, they mean several things. After many chilly days, a milder yet still cold day is "warm."
- Humans filter and assess data, so they may use it to draw conclusions or not utilize it if they want.
- Fuzzy logic computers are beneficial when there are too many jobs for individuals to analyze and act independently.
- Many things are unclear, and fuzzy logic is an excellent approach to dealing with them. People utilize fuzzy logic to interpret data sets.

Probabilistic Reasoning

Many people think that statistical and probabilistic reasoning isn't the same thing. They're not the same thing either.[51–53] Most of the time, people make probabilistic judgments about events that are unique, one of a kind, or one of a kind when there isn't any relevant data to back them up. In a lot of different situations, this is true. Put another way, probabilistic ideas that aren't based on numbers need to be used. The world can't be replayed 1000 times to figure out how many bad things the defendant did or how many times a witness told us about an event. With more people interested in Bayesian statistics, it started to be used in many situations where getting accurate statistics is hard or impossible. People use this system to figure out how possible and likely things will happen in the future.[54–56] In the next step, computers figure out what the required probabilities should be based on these decisions. People came up with the idea of PIP, but it didn't last long. The more time went by, people realized that evidence-based decisions aren't just based on what might happen in the future.[57] When they want to connect data to interesting hypotheses, they need complex arguments or chains of reasoning. These kinds of inferences are called cascaded, catenated, or hierarchical and are used to make sense of things. When people make assumptions like this, they use words like this to describe them. Chains of reasoning like this one help us show that evidence has three essential qualities: relevance, credibility, and inferential force.[58]

People who have done many evidence-based studies and worked in the law were handy because they could think about complicated probabilistic reasoning. The idea of conditional nonindependence is the main one. Putting two or more things together can mean very different things than the thought of being alone or alone.[59,60]

Conclusion and Future Scope

Soft Computing techniques in different fields help make well-informed decisions easily and quickly. They are used to make the systems intelligent by using complex algorithms. As discussed in the paper, these techniques can be used in almost all fields. Their use is growing fast, and its impact can be seen clearly in the coming years. Intelligent systems and soft computing techniques are becoming more critical as the power of computer processing devices increases, and their cost is reduced. Intelligent systems must make complex decisions and choose the best outcome from many possibilities using complex algorithms.

Using soft computing techniques and building intelligent systems has become more critical than ever. Nowadays, most soft computing applications can be handled efficiently by low-cost but super-fast microcontrollers. Many industrial and commercial applications of soft computing are also in everyday use, which is expected to grow within the next decade. The author believes that the soft computing theory, techniques, and applications will increase with IoT devices in domestic, industrial, and commercial markets.

Conflict of Interest

Authors declare no conflict of interest is there for publication of this work.

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