



Integrating N-person Intuitionistic Neutrosophic Soft Games with Neutrosophic Cognitive Maps for Cloud Storage with Accounting Information Systems

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Abstract

Neutrosophic logic is founded on non-standard evaluation. In neutrosophic set (NS), the computation of indefiniteness is explicit, while the membership of truth, falsity, and indeterminacy are non-reliable. Recently, various attractive game theory application is extended by entrenching the fuzzy set logic. The accounting data analysis has to contribute the innovativeness. This includes various characteristics. It applies billions of individuals in the business to develop and design novel products until the sale managing of the enormous sales staff. While cloud storage provides flexibility and scalability, it also comes with related costs, involving data transfer fees, subscription fees, and storage costs. Optimizing and managing cloud storage costs associated with business needs and budgetary constraints is crucial. Cloud-based AIS decreases the necessity for localized infrastructure and hardware, oscillating rate from capital to operational expenditure. This enables organizations to pay only for the used resource, resulting in economic efficiencies. Incorporating cloud technology into accounting information systems (AIS) provides several advantages. To increase the capability of accounting data statistics and analysis, this article introduces an N-person intuitionistic neutrosophic soft game with Neutrosophic Cognitive Maps (NINSG-NCM) for cloud storage with AIS. The NINSG-NCM technique considered a contemporary accounting data analysis is built based on the block bit sequence evaluation technique and extracts the association rule representative amount of accounting data. Integrated with cloud computing (CC) framework, the NINSG-NCM method is proposed, and the NCM clustering technique is used for realizing the modern accounting data clustering, and the NINSG method could enhance the capability of statistical analysis and parallel computing of accounting data. Lastly, salp swarm algorithm (SSA) is applied for hyperparameter tuning method. The experimental outcomes illustrate that the designed intelligent data evaluation technique makes the parallel computing efficacy high and the statistical evaluation capability of accounting data better.

Keywords: Accounting Information System; Neutrosophic Cognitive Maps; Salp Swarm Algorithm; Cloud Computing; Neutrosophic Soft

1. Introduction

A NS was presented as a model for studying neutral ambiguous data. It is categorized via three memberships, T , and F . The NS introduces a symmetrical model, as enrolment of truth T is symmetrical to its contrary F concerning indeterminat enrolment I , which play as symmetrical axis. The NS was additionally prolonged to a Q-neutrosophic soft set (NSS) that is a fusion technique that has the NSS aspects while handling ambiguity, and the Q-fuzzy soft set factors that deals 2-D data. Accounting utilizes outcomes as the foremost point of measurement; the foremost intention is to enhance the company; it mainly utilizes superior models for organizations and companies; and it contains comprehensive, constant, and business management [1]. Management, predicting, economic reporting, registration, decision-making, observing, business and social growth are main fragments of the significance of business organization [2]. With aid of data age, traditional accounting has been transformed from physical bookkeeping, physical control, and physical verification to utilising computers to perform equivalent work.

However, these kinds of tasks were transmitted from traditional physical to computer computation, and only the physical calculation was passed over to the computer [3]. The statistical models, data entry, and other procedures need a lot of physical contribution. In this case, accounting information technology is dependent upon the computer, but individuals are employed to compute the objective data and company entities, and the real operation method and work platform are quite implemented in customary accounting [4]. With the constant simplification of computers, the functions are more dominant, concerning all features of society, and its foremost functions are emerging near computerizing and intellect, its key function stays on calculation [5].

Owing to the vast growth predictions of CC

, all businesses have enlarged their prominence on CC, and the growth of CC should become the trend of informatization [6]. CC has numerous functions to avert main disasters, complete spreading and distribution, and share data quickly. Gangyan research displays that urban flooding is the biggest disaster all over the world [7]. While numerous models and enterprise information systems (EIS) are intended for urban flood shields, the ineffectual organization of physical assets has significantly delayed their utilization [8]. Handling numerous physical assets is vital for urban flood control. There are difficulties in sharing services and assets among agents and certifying real and flexible decision support [9]. This work projects a cloud-based asset management platform. Implement cloud technology to procedure huge quantities of data gathered from numerous physical assets and deliver flexible access interface [10]. A service-oriented model was used to simplify the distribution of services and assets and permit the growth of scalable and flexible decision support systems (DSS).

This article introduces an N-person intuitionistic neutrosophic soft game with Neutrosophic Cognitive Maps (NINSG-NCM) for cloud storage with AIS. The NINSG-NCM technique considered a contemporary accounting data analysis is built based on the block bit sequence evaluation technique and extracts the association rule representative amount of accounting data. Integrated with CC framework, the NINSG-NCM method is proposed, and the NCM clustering technique is used for realizing the clustering of modern accounting data later NINSG method could enhance the capability of statistical analysis and parallel computing of accounting data. Lastly, salp swarm algorithm (SSA) is applied for hyperparameter tuning method. The experimental outcomes illustrate that the designed intelligent data analysis technique makes the parallel computing efficacy high and the statistical evaluation capability of accounting data better.

2. Literature Survey

Sun [11] builds a cloud accounting IT audit method dependent upon the technology of big data (BD). At initial, the companies' comfort, effectiveness and operation ability were seized as the displays of economic position, and the assessment index method was built. Next, the data were pre-processed, after which the diagnostic hierarchy procedure was employed to examine the data and define the emphasis of audit. Akai et al. [12] examined the outcome of CC on the excellence of economic reports. Software as a service (Saas) and Infrastructure as a service (Iaas) are the CC substitutes used to determine their result on economic reporting excellence. Financial reporting quality (FRQT) model has been restrained by means of qualitative features of economic reports as delivered by IASB conceptual structure. Wang [13] proposed the application of technologies like CC to build an accounting information method centred nearby BD analysis. Dependent upon the values of platform structure, it places onward that the platform must include functions linked to complete economic analysis, economic observing, economic decision-making, and economic predicting. The paper also examines the platform's complete structure and delivers exact modules.

In [14], simulation methods of the stock market game utilizing DL have been utilized. Furthermore, intensive computation experimentations were executed to analyse the excellence of the solutions, which were defined by the projected DL methods utilizing ANN based on LSTM. The research offered in this paper was certified by pretending the probability of utilizing DL. Yang [15] proposed a new process, Heterogeneous Distributed DL with Data Offloading (DDLO) technique. Also, ML techniques are utilized. The developed DDLO algorithm promotes a hybrid ML model for calculating multi-tasking and joint tasks in accounting computerizing. In [16], the RSA model is employed to yield main codes for the privacy of the cloud service. The model is dependent upon a User End Generated (UEG) model which reduces the third-party contribution and increases safety checks. Also, numerous authorization-allocating approaches and block access outlines have been recognized together with existing operation design techniques. The suggested model makes use of BC technology.

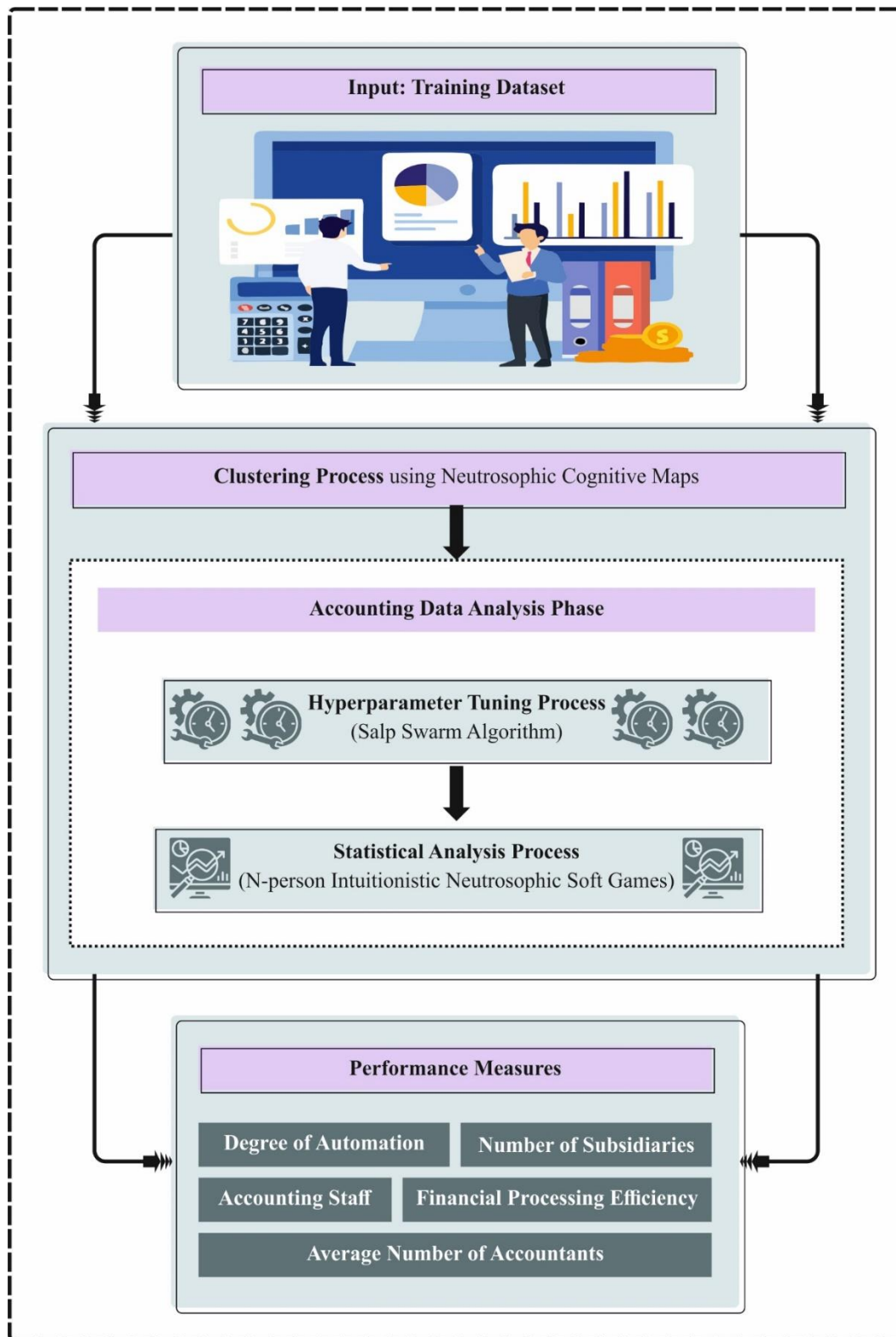


Figure 1: Workflow of NINSG-NCM approach

3. The Proposed Method

In this article, an NINSG-NCM technique is introduced for cloud storage with AIS. The NINSG-NCM technique considered a contemporary accounting data analysis is built based on the block bit sequence evaluation technique

and extracts the association rule representative amount of accounting data. Fig. 1 demonstrates the workflow of NINSG-NCM algorithm.

A. Design of NINSG-NCM method

NCM is an addition of classical cognitive maps, incorporating the neutrosophy method for dealing with contradiction, uncertainty, and indeterminacy [17]. Florentin Smarandache in the late 1990s introduced Neutrosoph concept, which generalizes preceding studies in fuzzy set theory, fuzzy logic, intuitionistic set theory, etc., to handle indeterminacy and uncertainty.

In NCM, the causal relationship is defined by the degree of membership (fuzzy cognitive map) or the Boolean value (false or true). This enables us to model situations where the relationships between the conceptions are inherently uncertain or completely known.

The real-world application of NCM needs an interdisciplinary method, uniting information from engineering, psychology, mathematics, and computer science, to efficiently model the real system complexity in uncertainty.

The following steps must be followed to create the NCM:

- **Concept detection:** Define the variables or concepts that apply to the problem or system being modelled. This concept ranges from real elements to theoretical ideas.
- **Description of Relationship:** Create the causal relations between them. This includes defining how a modification in one conception affects others. This relationship is not constrained to being negative or positive in the neutrosophic context, they must be taken under the truth, false, and indeterminacy degrees.
- **Task of Neutrosophic Value:** For the relationship and concept, allocate value that characterizes the truth, false, and indeterminacy degree. Usually, this value is formulated within $[0,1]$, where 0 refers to the comprehensive absence and 1 denotes the comprehensive existence of property.
- **Analysis and Simulation:** When the map is created, it simulates dissimilar situations and examines how variations in specific concepts may disturb the scheme. This necessitates a computation method to switch the difficulty of neutrosophic relations.

NCM, through uniting conceptions from cognitive maps with neutrosophy concepts, exploit an equation that helps analyze and model fundamental relations between impressions under situations of contradiction, uncertainty, and indeterminacy. This equation is grounded on the operation of NSs and neutrosophic logic, targeting to enumerate how variations in one conception disturb others in the map.

A NS is distinct by three mechanisms: the truth grade (T), the indeterminacy degree (I), and the falsehood degree (F), with elements ranges from $[0-1]$. The rudimentary definitions connected to neutrosophic are:

The NCM is a fixed neutrosophic graph, where edges characterize causal relations between vertices and vertices characterize conceptions.

Vertex Demonstration: If there are k vertices C_1, C_2, \dots, C_k , each represents the vector (x_1, x_2, \dots, x_k) , in which $x_i \in \{0,1,I\}$ depends on the vertex state C_i at definite or situation time. The vertex C_i state is represented below:

- $x_i = 0$: activated.
- $x_i = 1$: deactivated.
- $x_i = I$: indeterminate.

Relations amid vertices: The directed edge from C_m to C_n is known as a connection and characterizes causality from C_m to C_n .

Relationship of weight to all the vertex: Every NCM vertex is related to the weight inside $\{0,1,-1,I\}$. The edge weight $C_m C_n$, represented by α_{mn} , specifies the influence of C_m on C_n :

- $\alpha_{mn} = 0$: C_m does not influence C_n .
- $\alpha_{mn} = 1$: A decrease (increase) in C_m generates the decrease (increase) in C_n .
- $\alpha_{mn} = -1$: A decrease (increase) in C_m generates an increase (decrease) in C_n .
- $\alpha_{mn} = I$: The effect of C_m on C_n is indeterminate.

The NCM with edges and weights is known as a simple NCM.

If C_1, C_2, \dots, C_k are the NCM vertices. The neutrosophic matrix $N(E)$ is described by $N(E) = \alpha_{mn}$ and is known as NCM's neutrosophic adjacent matrix, in which α_{mn} represents the directed edge weight CC, where $\alpha_{mn} \in [0,1]$.

Consider C_1, C_2, \dots, C_k as the NCM vertices. $A = (a_1, a_2, \dots, a_k)$, in which $a_m \in \{-1,0,1,I\}$. A refers to the neutrosophic vector's instantaneous state and implies the indeterminate activated-deactivated vertex state location.

- $a_m = I$ When C_m is indeterminate (influence could not be defined).
- $a_m = 0$ When C_m is deactivated (has no influence),
- $a_m = 1$ When C_m is activated (takes influence),

Consider C_1, C_2, \dots, C_k and $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_m C_n}$ are the vertices and edges of NCM.

The NCM has cycles for having feedback, and if this in the NCM, it is called a dynamic system.

Consider $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_{k-1} C_k}$ as a cycle. Once C_m is stimulated and its connectedness streams above the cause of C_m and the cycle edges, then the dynamic system mingles. This is accurate for vertex C_m with $m = 1, 2, \dots, k$. The steadiness state is called hidden pattern.

If the steadiness dynamic system state is unique, which is represented as fixed point. The NCM settle on C_1 and C_k , viz., the state remained as $(1, 0, \dots, 0, 1)$, then the neutrosophic state vector is known as a fixed point.

Once the NCM is determined by the reiterating neutrosophic state vector of the form: $A_1 \rightarrow A_2 \rightarrow \dots \rightarrow A_m \rightarrow A_1$, then the steadiness is known as the NCM limit cycle.

There are numerous examples where INS games are frequently used to play among more than dual players [18]. Hence, there is a necessity to prolong Tp-ins-games to N-person-ins-games in numerous real issues.

Here, U_n^\otimes for $U_1 \times U_2 \times \dots \times U_n$ is utilized.

Definition4.1 Assume that Ω as an alternative set and IN^Ω denotes the set of every intuitionistic neutrosophic subset over Ω . While Ebe a set of tactics and U_1, U_2, \dots, U_n subseteq E and U_k refers to the set of tactics of Player k , if $k = 1, 2, \dots, n$. Next, for every Player k , an N -person-ins-games is definite by an INS set over Ω as

$\gamma_{U_n^\otimes}^k = \left\{ \left((u_1, u_2, \dots, u_n), \rho_{U_n^\otimes}^k(u_1, u_2, \dots, u_n) \right) : (u_1, u_2, \dots, u_n) \in U_n^\otimes \right\}$, whereas $\rho_{U_n^\otimes}^k$ is an INS-payoff function of Player k .

The N -person ins-game is illustrated below: at a definite time Player1 selects a tactic $u_1 \in U_1$ and at the same time every player $k = 2, 3, \dots, n$ selects a tactic $u_k \in U_k$ and when this is completed, every player k gets the ins-payoff $\rho_{U_n^\otimes}^k(u_1, u_2, \dots, u_n)$.

Definition4.2 Let $\gamma_{U_n^\otimes}^k$ be an N -person ins-game beside with its ins-payoff function $\rho_{U_n^\otimes}^k$, for $k = 1, 2, \dots, n$. Next, a tactic $u_k \in U_k$ is named an INS-dominated to another tactic $u \in U_k$, if

$$\rho_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u_k, u_{k+1}, \dots, u_n) \supseteq \rho_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u, u_{k+1}, \dots, u_n) \text{ i.e.,}$$

$$\mu_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u_k, u_{k+1}, \dots, u_n) \geq \rho_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u, u_{k+1}, \dots, u_n),$$

$$\delta_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u_k, u_{k+1}, \dots, u_n) \geq \delta_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u, u_{k+1}, \dots, u_n) \text{ and}$$

$$\gamma_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u_k, u_{k+1}, \dots, u_n) \leq \gamma_{U_n^\otimes}^k(u_1, u_2, \dots, u_{k-1}, u, u_{k+1}, \dots, u_n), \text{ for every tactic } u_i \in U_i \text{ of player } i = 1, 2, k - 1, k + 1, \dots, n \text{ correspondingly.}$$

Definition4.3 Let $\gamma_{U_n^\otimes}^k$ be an N -person ins-game beside with its ins-payoff function $\rho_{U_n^\otimes}^k$. If for every player $k = 1, 2, \dots, n$, the subsequent property holds true

$$\rho_{U_n^\otimes}^k(u_1^*, u_2^*, \dots, u_{k-1}^*, u_k^*, u_{k+1}^*, \dots, u_n^*) \supseteq \rho_{U_n^\otimes}^k(u_1^*, u_2^*, \dots, u_{k-1}^*, u, u_{k+1}^*, \dots, u_n^*) \text{ , for every } u \in U_k, \text{ then } (u_1^*, u_2^* \dots u_{k-1}^*, u_k^*, u_{k+1}^* \dots u_n^*) \in U_n^\otimes \text{ is named an INS-Nash equilibrium of an N- person ins-game.}$$

B. Design of SSA for Hyperparameter Tuning

Lastly, the SSA is applied for hyperparameter tuning method. Salps are pelagic animals that feed on plankton in the marine environment [19]. They aggregate in long chains during the non-reproductive stage. The salp aggregation behavior is the basis of the SSA. The head and the tail are two different parts the SSA splits. The head, which takes the lead, is responsible for food searching, whereas the tail closely follows behind. The location $X = (x^1, x^2, \dots, x^D)$ of salp in SSA evaluates the fitness salp values from the fitness function $F(X)$. It is arranged according to FF from higher to lower and divided into two groups after the salp population is initialized within the search space. The initial group (leader), is considered superior in random fitness terms, whereas the second (follower), trails behind. The leader strives to discover a new location closer to the global optimum solution, whereas the follower maintains the location relative to its prior individuals. Fig. 2 depicts the flowchart of SSA.

Leader behavior

At all the iterations, the leader in a population is selected according to the individuals with the high fitness score. It leads the overall population to search.

$$\begin{cases} x_{new,i}^d = x_{best}^d + C1 \times (C2 \times (x_{max}^d - x_{min}^d) + x_{min}^d) & C3 \geq 0.5 \\ x_{new,i}^d = x_{best}^d - C1 \times (C2 \times (x_{max}^d - x_{min}^d) + x_{min}^d) & C3 \leq 0.5' \end{cases} \quad (1)$$

$$C1 = 2e^{-4\left(\frac{iter}{iter_{max}}\right)^2}. \quad (2)$$

$C2$ indicates the uniformly distributed random value within $[0,1]$, X_{max} and X_{min} are the upper and lower boundaries of the search space, $C1$ used to balance the relationships between exploration and exploitation, whose values range within $[2/e^4, 2]$, $C3$ refers to the random value within $[0,1]$ and the leader selects its mobile strategy based on $C3$. Generally, the leaders take the optimum location as the initial point and take the step towards a random location in the solution space.

Follower behavior

Eq. (3) describes the follower's behavior formula based on Newton's law of motion. If $i > 2$, x_j^i represents j^{th} dimensional individual salp, t is time, v_0 is the initial velocity, a is the acceleration, indicated as $\left(a = \frac{v_{final}}{v_0}\right)$.

$$x_j^i = \frac{1}{2}at^2 + v_0t. \quad (3)$$

Generally, time in swarm intelligence algorithms is widely regarded as the time it takes to iterate. The variance between the amount of iterations is considered as 1. Eq. (3) is expanded to Eq. (4). x_j^i refers to the j^{th} dimensions of the present i^{th} searching agent, x_j^{i-1} shows the j^{th} dimension of the existing $i - 1$ search agents.

$$x_j^i = \frac{1}{2}(x_j^i + x_j^{i-1}). \quad (4)$$

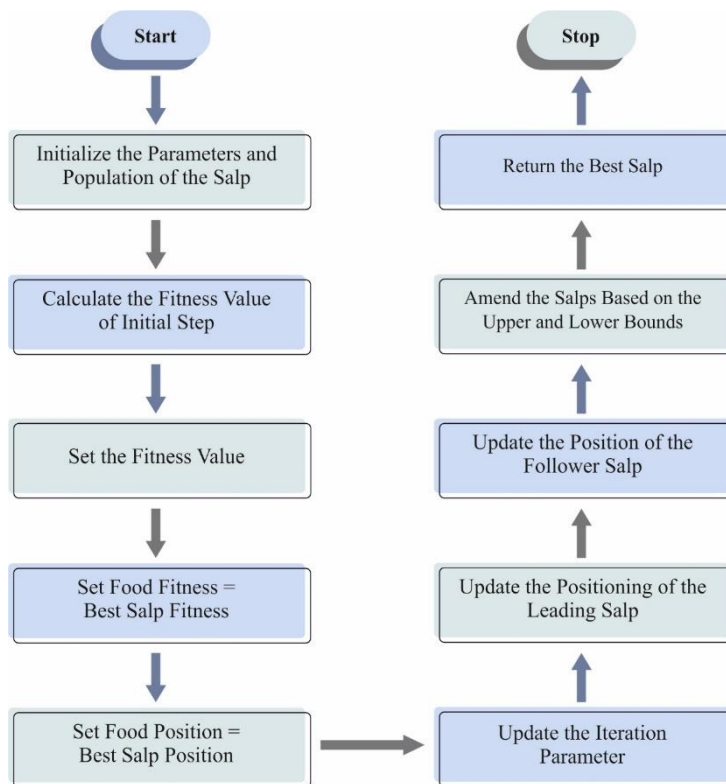


Figure 2: Flowchart of SSA

The SSA model is used to derive an FF for obtaining superior classifier results. It describes a positive integer to characterize the high efficiency of solution candidate. Now, the decline of classifier error is assumed as the *FF*.

$$\begin{aligned}
 fitness(x_i) &= ClassifierErrorRate(x_i) \\
 &= \frac{No. of misclassified samples}{Total No. of samples} * 100
 \end{aligned}
 \tag{5}$$

4. Performance Validation

In this section, the performance validation result of NINSG-NCM technique can be examined. Table 1 and Fig. 3 illustrate the comparative analysis of service quality before and after cloud sharing.

Table 1: Before and After Cloud Sharing

Types of	Before sharing	cloud	After cloud sharing
Degree of automation	40		99.55
Financial processing efficiency	6 day		40 hour

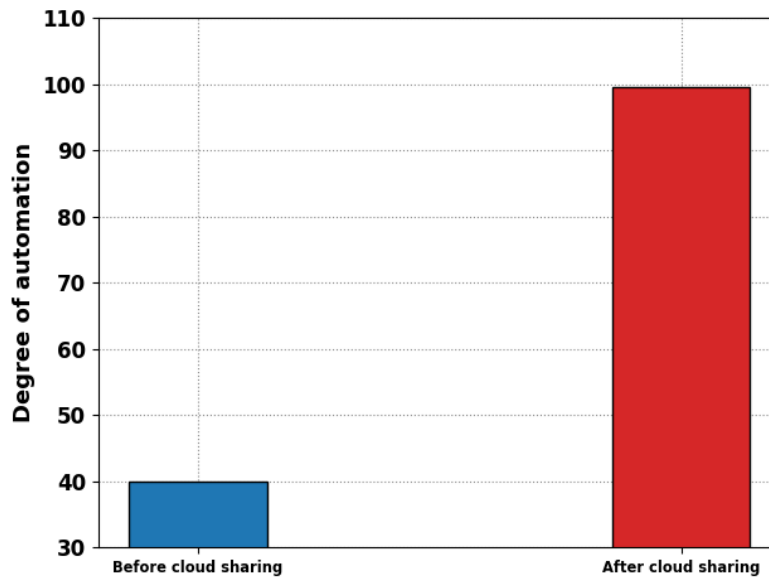


Figure 3: Before and After cloud sharing

Table 2 represents a detailed result of the NINSG-NCM technique [20]. Fig. 4 indicates the performance of the NINSG-NCM technique over several years and the number of subsidiaries (A). In 2012, the NINSG-NCM technique obtained the number of subsidiaries of 80. Also, in 2014, the NINSG-NCM method attains number of subsidiaries of 135. Meanwhile, in 2016, the NINSG-NCM method acquired number of subsidiaries of 150. Additionally, in 2018, the NINSG-NCM system attained number of subsidiaries of 250. Besides, in 2020, the NINSG-NCM method attains number of subsidiaries of 390. At last, in 2022, the NINSG-NCM system attains number of subsidiaries of 569.

Table 2: Classifier outcome of NINSG-NCM technique under several years

Years	Number of subsidiaries(A)	Accounting staff (person)	Average number of accountants
2012	80	1160	14.50
2013	90	1125	12.50
2014	135	1242	9.20
2015	145	1276	8.80
2016	150	1215	8.10
2017	155	1085	7.00
2018	250	875	3.50
2019	310	521	2.79
2020	390	301	2.00
2021	478	212	1.49
2022	569	105	0.98

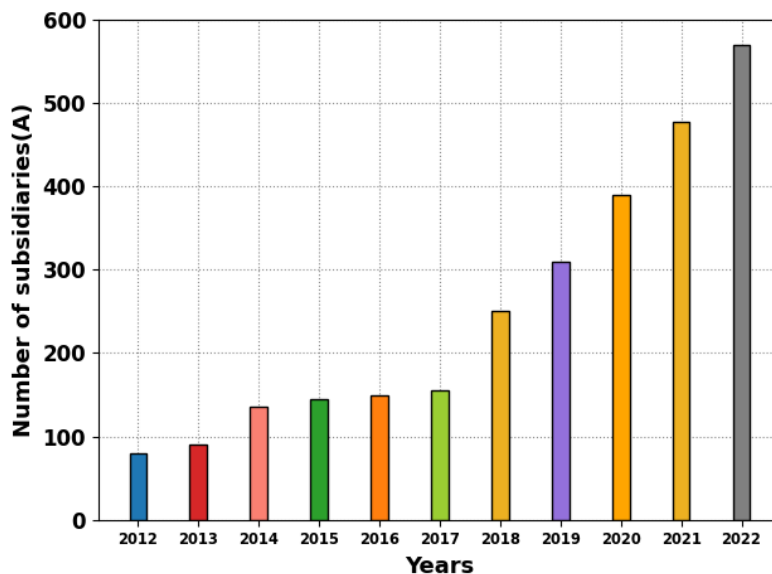


Figure 4: Number of subsidiaries outcome of NINSG-NCM technique under several years

Fig. 5 specifies the classifier results of the NINSG-NCM method under several years and accounting staff (person). In 2012, the NINSG-NCM system attained accounting staff of 1160. Also, in 2014, the NINSG-NCM system gained accounting staff of 1242. Meanwhile, in 2016, the NINSG-NCM model attained accounting staff of 1215. Furthermore, in 2018, the NINSG-NCM method attained accounting staff of 875. Besides, in 2020, the NINSG-NCM system attained accounting staff of 301. At last, in 2022, the NINSG-NCM method attains accounting staff of 105.

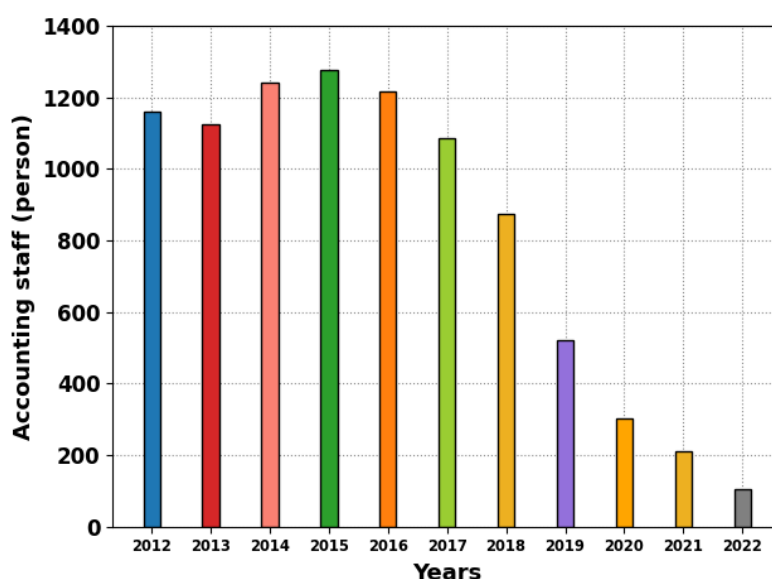


Figure 5: Accounting staff outcome of NINSG-NCM technique under several years

Fig. 6 specifies the performance of the NINSG-NCM method over several years and average number of accountants. In 2012, the NINSG-NCM system attained average number of accountants of 14.50. Similarly, in 2014, the NINSG-NCM method obtained average number of accountants of 9.20. Meanwhile, in 2016, the NINSG-NCM algorithm obtained average number of accountants of 8.10. Furthermore, in 2018, the NINSG-NCM approach attained average number of accountants of 3.50. In addition, in 2020, the NINSG-NCM model attained average number of accountants of 2.00. At last, in 2022, the NINSG-NCM method achieves average number of accountants of 0.98.

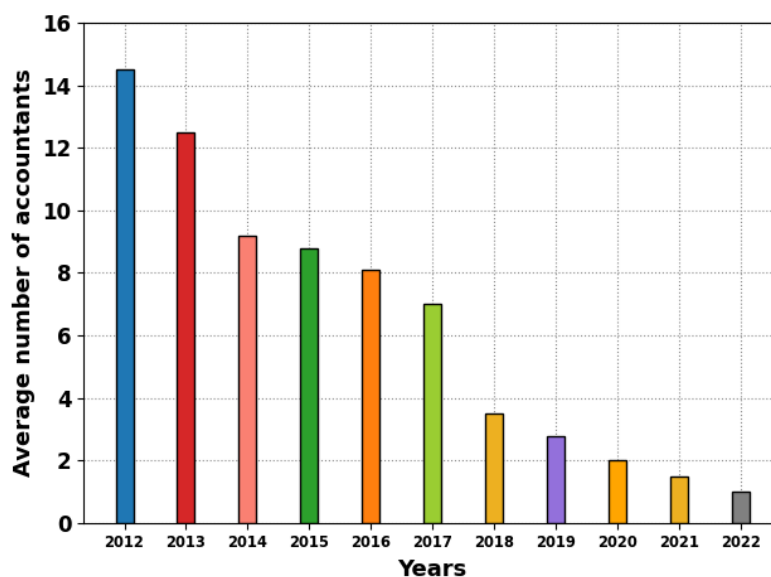


Figure 6: Average number of accountant's outcomes of NINSG-NCM technique under several years

5. Conclusion

In this article, an NINSG-NCM technique is introduced for cloud storage with AIS. The NINSG-NCM technique considered a contemporary accounting data analysis is built based on the block bit sequence evaluation technique and extracts the association rule representative amount of accounting data. Integrated with CC framework, the NINSG-NCM method is proposed, and the NCM clustering technique is used for realizing the clustering of modern accounting data later NINSG method could enhance the capability of statistical analysis and parallel computing of accounting data. Lastly, the SSA is applied for the hyperparameter tuning method. The experimental outcomes illustrate that the intelligent data analysis technique makes the parallel computing efficacy high and the statistical evaluation capability of accounting data better.

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