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Innovative design of stop mechanism and zinc stripping device integrating TRIZ tools

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Abstract

In order to solve the engineering problems of zinc stripping machines in the process of stripping zinc plates, such as shaking cathode plates, frequent jamming, and low success rate of stripping plates, this paper innovatively adopts the method of integrating TRIZ tools for problem-solving. Based on the TRIZ analysis problem theory, the innovative fusion of the triaxial analysis tool and the functional model analysis module is used to establish a systematic process and model for analyzing the problem, so that the analysis tools can be linked to each other and the analysis results can be avoided in isolation, thus identifying the problem efficiently and accurately. Finally, a stopping mechanism and a zinc stripping device are proposed. The stopping mechanism realizes the fixation of aluminum plates, which not only solves the engineering problems of shaking cathode plates, frequent jamming, and low success rate of stripping plates but also realizes the purpose of operation automation and reduces labor costs. The research results provide a reference for reducing the shaking frequency of the cathode plate and improving the success rate of the stripping plate in the zinc stripping machine, and further provide the improvement direction and ideas for the existing workshop management.

Keywords: TRIZ, Triaxial analysis, Functional model, Zinc stripping Device

1. Introduction

In China, with the continuous expansion of the mining speed and scale of mineral resources, the grade content of useful minerals gradually decreases. The mineral resources show the characteristics of poor, fine, and miscellaneous, which further aggravates the difficulty and complexity of metallurgical equipment and puts forward higher requirements for the design of metallurgical equipment flow and the development and optimization of metallurgical equipment. S., Yao. (2020) put forward for the processing and manufacturing enterprises of mineral processing equipment, it is more and more important to deeply understand the characteristics of discipline attributes, give full play to the technical advantages of interdisciplinary integration, and learn to use innovative theoretical methods and technical means, to better promote the overall rapid development of metallurgical equipment. In this case, TRIZ theory has successfully overcome the inertia of traditional thinking with its unique and systematic innovative thinking advantages, which is helpful to realize the high-quality leapfrog development of the metallurgical equipment manufacturing industry.

TRIZ theory is a solution to the invention problem, which was created by ALTSHULLER, a Soviet scholar. L. Fiorineschi et al. (1995) proposed that compared with the traditional innovation methods such as implementation error and brain transfer, TRIZ theory has obvious characteristics and advantages. At present, the most popular classical TRIZ analysis tools include the following: Inventive Problem-Solving

Algorithm (ARIZ), Substance-Field Analysis, and Contradiction Analysis. The latest TRIZ analysis tools will add functional mode, functional analysis, and causality analysis. Table 1 shows the TRIZ problem model.

In recent years, more and more scholars have begun to apply TRIZ theory to mining and metallurgy fields, and some achievements have been made. Wang et al. (2021) used TRIZ theory to solve the problem of low processing capacity in the engineering practice of inertial cone crushers and its mutual restriction relationship with the particle size of crushing products, and finally, nine solutions were obtained. The design example confirmed the feasibility of using the TRIZ method to realize innovative design in the production practice of metallurgical equipment. Nikulin, C et al. (2018) developed an effective and efficient solution tool of TRIZ, which addresses the influencing factors of risk detection and analysis from operational process reliability and takes a mining filter plant as an example to identify and classify current problems and generate solutions. Wei. (2015) solved the problem of cleaning the dielectric box of SLON-1750/2500 strong magnetic machine by using the object-field model method in TRIZ theory. Chen. et al. (2013) studied the application of TRIZ theory in the improved design of slime crushers and discussed the methods and concepts of using TRIZ theory to transform and design new slime crushers. Han et al. (2017) used the innovative theory TRIZ to solve the problem that the single filling system used in domestic mines has low production capacity and cannot meet the filling technical requirements of ultra-large-scale underground mines, and obtained 9 schemes. Yan et al. (2016) creatively put forward the comprehensive mining method of long wall sectioning, trench cutting, moving frame, and caving in view of the disadvantages of traditional mining methods for gently inclined and thin ore body mining, which effectively solved the problem of insufficient production capacity of the mine.

Wang et al. (2020) came up with the above research that have provided beneficial enlightenment for the development of TRIZ theory in the field of mining and metallurgy. However, in practical applications, engineers cannot efficiently and accurately identify the key problems when using causal and functional models and other analytical tools due to the particularity of mining and beneficiation equipment. Many practices have provided important evidence that it takes a long time to solve the key problems of complex equipment, even for experienced technicians. It may also cause deviations in the direction of solving problems due to preconceived ideas.

Therefore, to achieve the purpose that engineers and technicians can timely and accurately identify the root cause behind the problems, and strengthen the interaction and connection between the analysis tools, this paper innovatively integrates the triaxial analysis tools and the functional model analysis module based on the TRIZ analysis problem theory, establishes a systematic process and model for analyzing problems, and analyzes the rationality and feasibility of the innovative process with the engineering problem examples of the mineral processing equipment-zinc stripping machine's shaking cathode plate, frequent jamming, and low success rate of stripping plate. The research results provide a reference for reducing the shaking frequency of the cathode plate and improving the success rate of the stripping plate in the zinc stripping machine.

Table 1. TRIZ problem model.

Problem model	Tool	Solution model
Technology contradiction	Contradiction matrix	40 invention principles
Physical contradiction	Separation method	Separation principle, 40 invention principles
Substance-Field model function model	Substance-Field Analysis	76 standard solutions, 40 invention principles

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2. TRIZ problem solving process integrating triaxial analysis and functional model

Yan et al. (2019) presented functional analysis as an important part of the technical system analysis phase, whose main purpose is to transform abstract systems into a specific chart so that engineers and technicians can understand the functions and characteristics of the system required. Therefore, by defining and describing the functions that the system components need to achieve, as well as the interaction between components or with the external environment to analyze the overall system, it can assist engineers and technicians in making complex into simple and rationally carry out an innovative design.

In the process of functional analysis, the most important step is to establish the functional structure or functional model of the system. First of all, it is important to find the main functions of the existing technical system and make it achieve the best state. Wang (2021) proposed it is necessary to find out the harmful, insufficient, and excessive functions of the system to find out the problems of the system and then solve the existing problems completely. In addition, the triaxial analysis is integrated into the existing TRIZ problem-solving process to facilitate the integration of analysis tools. The three axes include the causal axis, operation axis, and system axis. Bai et al. (2020) came up with the purpose of triaxial analysis to analyze and define the initial problem from all aspects, decompose the complex engineering problem into several sub-problems, make full use of system resources, and find the root cause of the problem.

After fusion, the TRIZ analysis and identification problem process is formed, as shown in Figure 1. New engineering problem requires the process of information collection, resource analysis and ideal solution in the early stage. When the preliminary work is properly prepared, it enters the causal axis analysis. It addresses the root cause of the locking problem and its possible results by the normalized description and also provides a good foundation for the next step to determine the key points of the problem in combination with the functional model. Zhu et al. (2021) proposed system axis analysis is based on the functional analysis of the interaction information of the existing technical system components and the establishment of a functional model, combined with the root cause of the location and weaknesses.

The innovative model of integrating triaxial analysis and functional analysis combines their respective characteristics. The causal axis obtains the root cause of the problem and the starting point of solving the problem; the system axis eliminates the root cause from the technical system through component analysis and functional model. The operation axis provides direction for solving problems by improving the operating process.

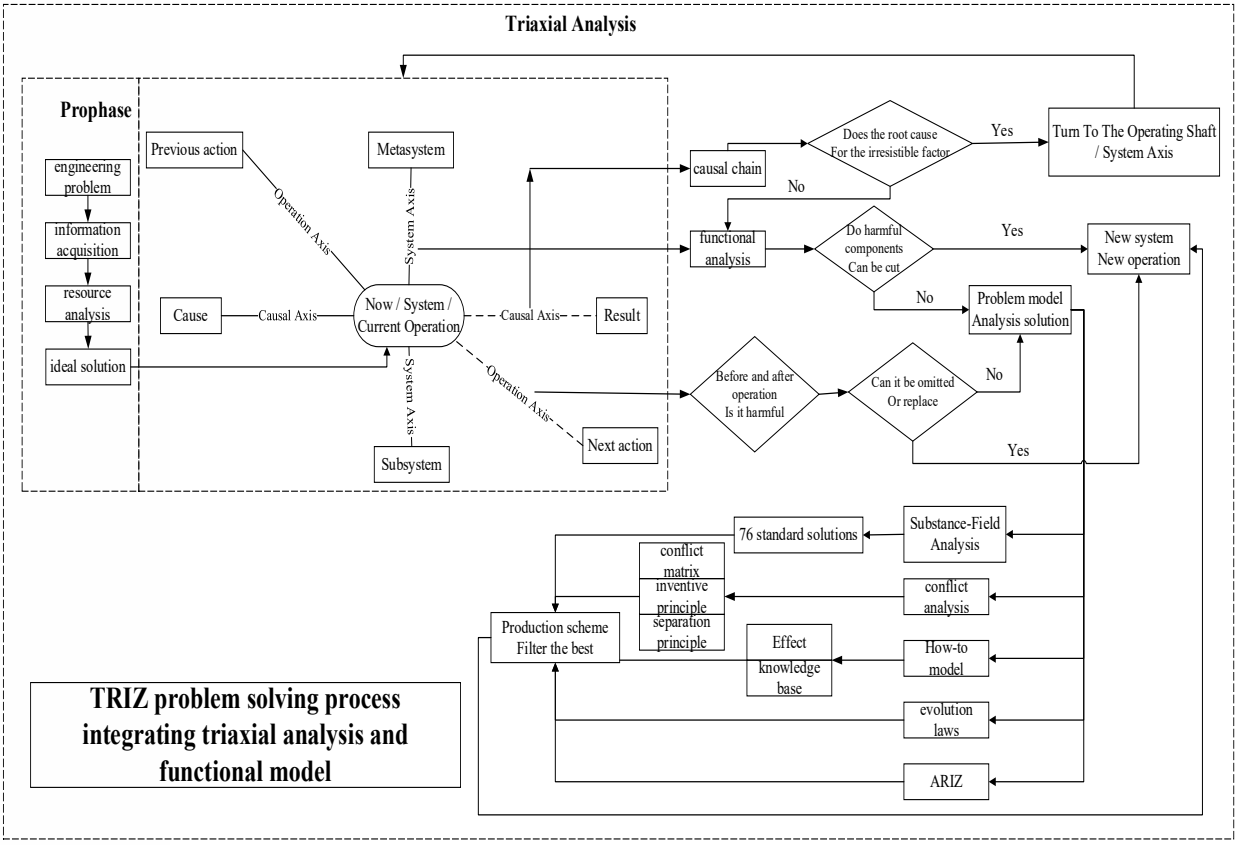

Fig. 1. TRIZ analysis problem flow chart combining triaxial analysis and function model.

3. Project case analysis

3.1 Pre-information collection

There are two methods of zinc smelting, one is called zinc pyrometallurgy, and the other is called zinc hydrometallurgy. Zinc pyrometallurgy uses zinc concentrate as raw material to make calcine by roasting, then distilling the calcine and condensing its zinc vapor to obtain crude zinc. Refined zinc containing more than 99.9% zinc can be prepared from the distillation of crude zinc. Jiang et al. (2022) came up with zinc hydrometallurgy is the roasted sand by solution leaching, the resulting leaching solution is purified to remove impurities. and then it is sent to the electrolytic cell for electrodeposition, and a layer of zinc metal will be generated on the electrolytic cell cathode plate. The layer of zinc will be stripped from the cathode plate and melted into a zinc ingot, which is the finished zinc.

However, stripping metal zinc from the cathode plate is heavy manual labor, especially in the zinc electrolysis workshop. The acid mist is very heavy and the environment is harsh, making manual stripping zinc a very difficult task.

To solve this problem, major zinc smelters in the world have developed and applied zinc stripping machines. Yuan. (2020) presented especially with the development of production scale and large-scale equipment, the plate is too large and heavy, which has exceeded the manual completion of zinc stripping operation limit, and the production cannot be maintained without the application of a zinc stripping machine.

The working principle of the stripping operation of the zinc stripping machine is to increase the pre-stripping before the stripping is applied. The purpose is to make the zinc sheet partially split the gap from the cathode aluminum plate so that the next operation is easy to feed. However, due to the long-running time of the pre-stripping zinc process of the zinc stripping machine, with the movement of the cathode plate aluminum plate on the transmission device, the large weight of the cathode plate will cause the cathode plate to shake. In the process of upward lifting of the zinc stripping blade, the lower edge of the aluminum plate is easy to collide with the head of the tool holder, and it

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is easy to happen stuck knife accident, resulting in the top of the entire automatic zinc stripping production line.

One of the current treatment measures is to adopt an artificial hook plate for auxiliary treatment on the equipment site. Each production line needs 2 manual workers to hook the lower edge of the aluminum plate every day to ensure that the aluminum plate does not shake and can fall into the tool holder for zinc stripping process. However, two manual hooks are used to operate the cathode plate because of the shaking of the cathode plate, which is a non-value-added operation and increases the operating cost.

Fig. 2. Existing treatment measures of pre-stripping process.

Because the lower edge of the aluminum plate is easy to collide with the head of the tool holder, the feedback of the manual blocking effect is not ideal, and the ideal solution is not obtained by using TRIZ tool analysis many times.

Given this problem, the improved TRIZ analysis process analysis is used. The new technical system requires the function of blocking objects, to control the sloshing of the aluminum plate, avoid the phenomenon of the stuck knife, and make the blade work normally.

The system's resource analysis list is shown in Table 2.

3.2 Problem analysis stage

The technical system of the current problem is a manual auxiliary scraper pre-stripping zinc system. The function of the technical system is to separate the zinc layer in advance. The constraints to achieve this function are good manual operation and high scraper efficiency. The working principle of the current problem system is that the equipment site now adopts an artificial hook plate for auxiliary treatment. Each production line needs 2 workers to hook the lower edge of the aluminum plate every day to ensure that the aluminum plate does not shake and can fall into the tool holder for zinc stripping process.

For pre-stripping system analysis, the causal axis analysis is first entered to understand the root cause of the event, find the problem entry point. The resulting graphical specification is shown in Figure 3.

According to the causal chain constructed, the causal relationship between the root cause of the problem and the result produced is clarified. After confirming that the problem can be eliminated, the system axis is transferred for functional analysis and functional modules are established, as shown in Figure 4.

In this system, since the zinc element from the electrolytic cell is attached to the surface layer of the aluminum plate, the aluminum plate will shake with the movement of the suspension beam, which will cause the aluminum plate not to accurately enter the scraping range of the scraper. The current system's meta-system components and subsystem hooks act on the scraper. Specifically, the human hand holds the hook and hooks the aluminum plate to ensure that it enters the scraping range of the scraper. It can be seen from the functional model that the supporting effect of the hook on the aluminum plate is a non-value-added operation, and it cannot guarantee that each aluminum plate enters the scraping range of the scraper. The supersystem component person lacks the force on the hook because the person feels tired. The air of the metasystem component will oxidize the electrolytic zinc to a certain extent. The longer the beat of the zinc scraping process, the more serious the degree of oxidation, which will lead to unnecessary impurities such as zinc oxide (ZnO) in the melted zinc solution.

The conflict component and causality axis analysis combined with the function model lock the key points in two aspects: (1) the adhesion between the zinc layer and the aluminum cathode plate is strong; (2) Track frame forward speed is fast.

Table. 2. Resource analysis list of the system.

resource type	available resources		Resource availability evaluation
physical resources	in-house resources	Aluminum material plate	Not available, aluminum plate is used for electrolytic zinc, the function does not match.
		Steel frame	Available, steel occupies most of the material, and the realization of the ideal solution can be associated with it.
		timber	Not available, which is insufficient or harmful effect, should not be used as available resources.
	external resources	temperature	Not available, there is little connection between the workshop temperature and the system.
Field Resources	external resources	barometric pressure	The conditions for the use of air pressure resources are harsh, and magnetic field resources can be used instead.
		mechanical field	Available, mechanical field exists between mechanical equipment, ideal solution can be associated with it.
		thermal field	Unavailable, the thermal field of the supersystem may also be harmful.
	in-house resources	mechanical field	Not available.
		magnetic field	Available, can be generated from the positive charge of zinc （Zn^{2+}） magnetic field as a variable to start.
space resources	in-house resources	Space between the top and bottom of cantilever beam	It is possible to use space resources, and add or improve mechanical equipment.
time resource	in-house resources	Time interval of aluminum plate transmission	Available, interval times may provide a new separation scheme.

3.3 Generation Scheme Screening Optimal

Key point 1: “zinc layer and aluminum cathode plate between the adhesion strength” is taken as the starting point to solve the problem. In this problem, the aluminum plate as the cathode plate in the electrolyzed zinc, can only be by following the usual manual auxiliary zinc stripping machine to operate. This is because the zinc layer is electrolyzed to the cathode plate. As the electrolysis time increases, the zinc element is precipitated and slowly added, and the adhesion between the aluminum plate is increasing.

Tool 1 is the Technology Conflict Resolution Theory.

The Angle of the problem is to reduce the force between the zinc layer and the aluminum plate. Since the cathode plate is suspended above the rail frame, under the influence of gravity, the force between the zinc layer and the aluminum plate should be increased to prevent the zinc layer from falling off during the forward process of the cathode plate. If the force increases, a scraper is required to strip zinc. This requires manual use of hooks to assist in zinc stripping, which is also a non-value-added operation. According to the four principles of ECRS, the force between the zinc layer and the scraper should be reduced. However, if the force between the two is reduced, the speed of the rail frame will not change due to the decrease of the adhesion force, which will lead to the shedding of the zinc layer during the transportation process and the decrease of the output. The force between the two forms a pair of technical conflicts.

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The conflict is described. The goal is to reduce the sloshing amplitude of the cathode plate. The way of action is to reduce the forward speed of the cathode plate carried by the rail frame. The result of the deterioration is that the zinc stripping process has a long beat and the output is reduced. Improved engineering parameters: 38 degrees of automation, 39 productivity, deteriorated engineering parameters: 23 material loss. Therefore, regarding the conflict matrix, the corresponding invention principles are No.35 parameter change, No.10 pre-operation, No.28 mechanical system replacement, No.18 vibration, and No.23 periodic action. Filter the best solution: the previous scraper to high-pressure water knife, the function is to separate the object, and the high-pressure water knife will not exist in the lower edge of the cathode plate and its stagnation.

Tool 2 is the Physical Conflict Resolution Theory.

To "reduce the sloshing amplitude of the cathode plate", the speed is required to be "low", but to "not affect the yield", the speed is required to be "high", in other words, the forward speed of the track frame carrying the cathode plate should be both "high" and "low". Considering that the "sloshing of cathode plate" has different characteristics in different "space, condition" (space, period time, different condition, system level), the conflict can be separated from "space, time" (space, time, condition, whole and part). The invention principles corresponding to the separation principle are the "No.1 segmentation principle, No.25 self-service principle, No.22 harm-benefit principle, No.24 mediator principle". The optimal solution is selected, and the conflict between the cathode plate and the scraper is separated from the perspective of time. Based on ensuring the uniform straight-line progress of the transmission device, the time interval and frequency of the cathode plate shaking are used. When the cathode plate is in the opposite direction of the scraper scraping range, pre-stripping can effectively avoid conflicts.

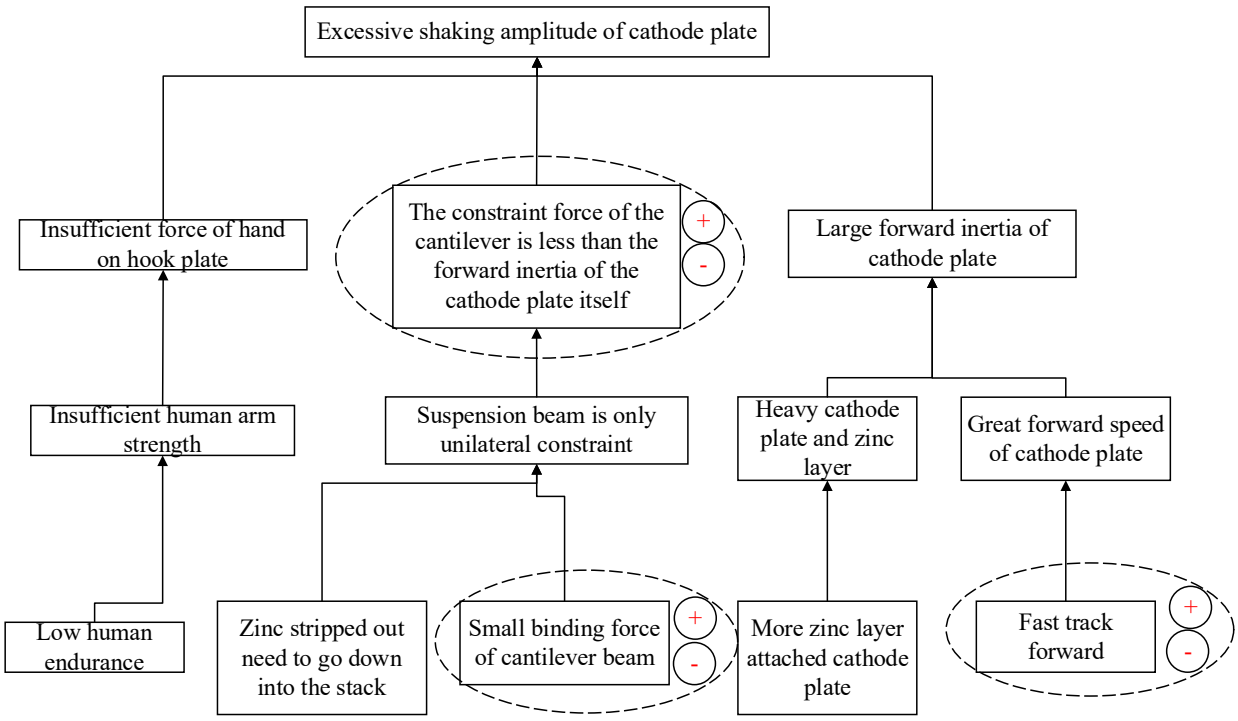

Fig. 3. Causal axis analysis of pre-stripping system.

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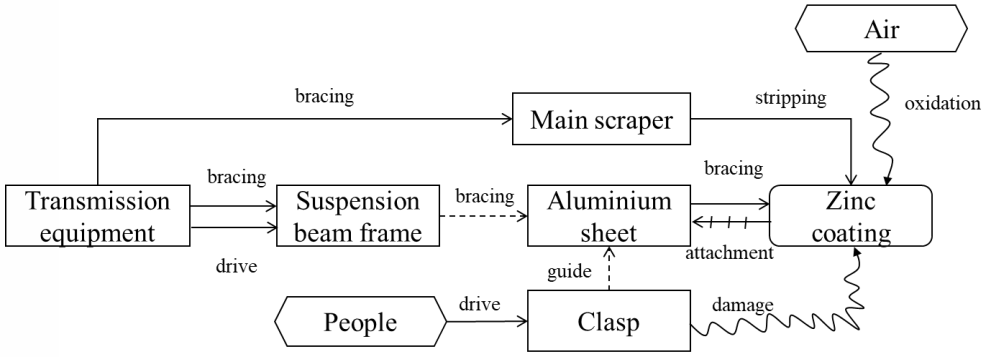


Fig. 4. Function model of pre-stripping system.

Key point 2: "fast forward speed of the rail frame" is the starting point to solve the problem. According to the problems reflected by the functional model, the material field model is established. The material field model of the original system and the material field model of the improved scheme are shown in Figure 5.

This material field model belongs to the insufficient action model. The problem in this model is that the hook has an insufficient blocking force to the cathode plate, which belongs to the insufficient interaction.

According to the material-field model of the problem, the standard solution compute process is applied, and the standard solution is obtained as the first type of standard solution No.7 (1.1.7): the field strength in one system is not enough, and increasing the field strength will damage the system. A field with enough strength will be applied to another component, and then the component will be connected to the original system. Similarly, a substance cannot work well, but it can work when connected to another available substance. Based on this, two schemes are obtained, and the optimal one is to replace the function of the manual and hook with the cost and easier control of the stop lever. By adding a gear bar device, the switch is used to control the lifting of the gear bar, control the sloshing of the aluminum plate, promote the blade to work normally, and eliminate the insufficient effect.

4. Optimal scheme and main mechanism design

Combined with the TRIZ problem-solving process mentioned above, this paper designs a stop mechanism and zinc stripping device. The design diagram is shown in Fig.6. The stopper mechanism comprises a stopper part and a driving part. The stopper part comprises a first stopper rod and a second stopper rod arranged at intervals, and the driving part is used for driving the stopper part to move to the moving path of the aluminum plate or to move away from the moving path of the aluminum plate; the first stop bar and the second stop bar are used to stop at the front and rear sides of the aluminum plate respectively when the first stop bar and the second stop bar are in the movement path of the aluminum plate to prevent the aluminum plate from shaking. In the initial stage, the top part is outside the motion path of the aluminum plate. Before the zinc stripping blade rises upward, the drive part can be used to drive the stop part to move into the motion path of the aluminum plate, and the stop limit of the aluminum plate in front of the stop mechanism is carried out. The first stop bar and the second stop bar are used to stop the front and back sides of the aluminum plate respectively, to avoid the collision between the lower edge of the aluminum plate and the head of the tool holder during the upward lifting of the zinc stripping blade, and the knife sticking accident occurs. When the zinc stripping knife operation is completed, the drive part can be used again to drive the stop part to move away from the motion path of the aluminum plate, to prepare for the stop of the next aluminum plate. By using the stop mechanism, the aluminum plate can be fixed, the purpose of operation automation is realized, and the labor cost is reduced.

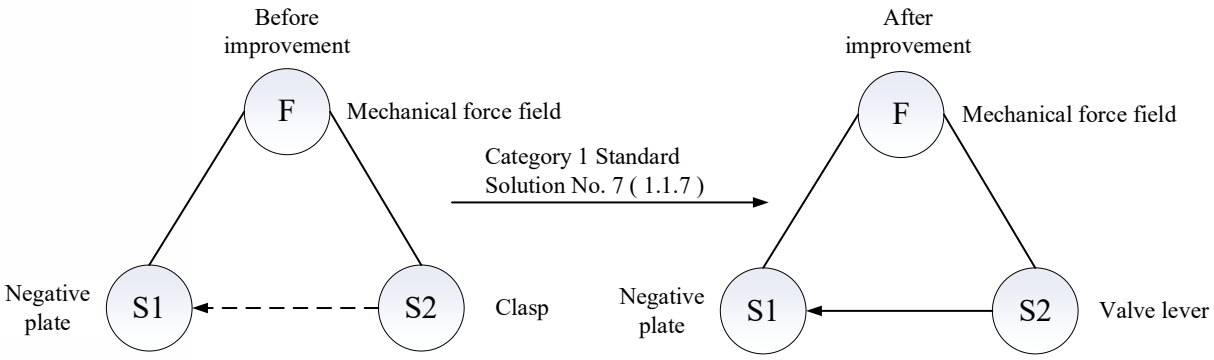
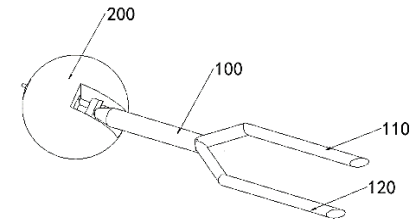
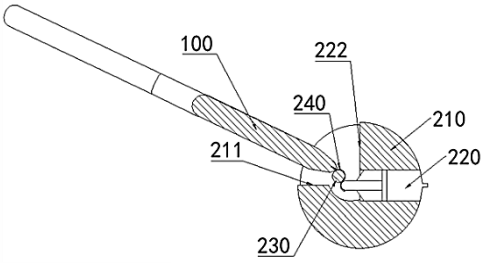


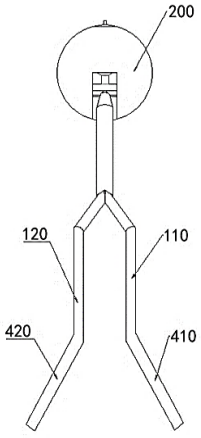
Fig. 5. Substance-field model.



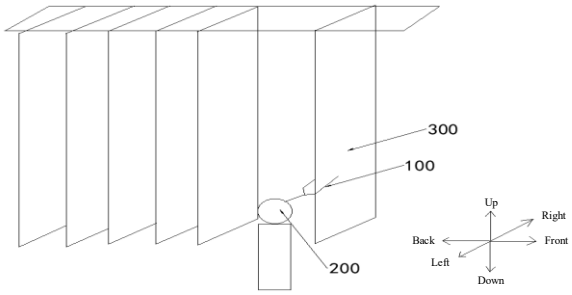
a. Stop mechanism diagram



b. Section view in A-A direction



c. Top view of stop mechanism



d. Schematic diagram of stop mechanism implementation

100-stopper; 110-first gear lever; 120-second gear lever; 200-Drive unit; 210-mounting seat; 211-Support plane; 222-stop surface; 220-expansion cylinder; 230-shaft; 240-warp board; 300-Aluminum plate; 410-first guiding rod; 420-Second guiding rod.

Fig. 6. Structure schematic of a stop mechanism and zinc stripping device.

5. Conclusion

Guided by the classical TRIZ concept, this paper integrates the triaxial analysis and functional model to solve the engineering problems of zinc stripping machine in the process of stripping zinc plate, such as shaking cathode plate, frequent jamming, and low success rate of stripping plate in zinc stripping machine, and it gets the corresponding solution. In this process, to solve the outstanding problems such as the path of technological innovation, the inaccurate identification, and the definition of core key problems in solving practical engineering problems, this paper analyzes the current situation of the analysis tools such as causal analysis and functional model used by engineers and technicians in TRIZ analysis to solve engineering problems. Through the innovative

integration of triaxial analysis and functional model, a new TRIZ analysis problem process is formed. The new process strengthens the interaction between analysis tools, timely and accurately redefines the problem, locks the key factors affecting the occurrence of the problem, and finally realizes the identification of the core key problems of the project. The stop mechanism of the final scheme can realize the fixation of the aluminum plate, which not only solves the engineering problems of the shaking cathode plate, frequent jamming, and low success rate of the stripping plate but also realizes the purpose of automatic operation and reduces the labor cost. The research results provide a reference for reducing the shaking frequency of the cathode plate and improving the success rate of the stripping plate in the zinc stripping machine, and further provide the improvement direction and ideas for the existing workshop management.

However, the research time of this paper is short, and the experience is limited. In the future, it still needs to carry out continuous optimization and design of the scheme.

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Deep attention network with sentence-level classification-based sentiment analysis in Telugu considering linguistic feature

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Abstract

Sentiment analysis in conversations has gained increasing attention for the growing number of applications like human-robot interactions. Inaccurate emotion identification in existing sentiment analysis methods is due to a lack of concentration on explicit and implicit factors in sentiment detection. Hence a novel deep attention expression analysis technique has been introduced in which a deep attention network with parallel level fuzzy classifier identifies the nature of the words using sequential word N-gram functions by incorporating distributed semantics thereby the implicit and explicit nature of the sentence is identified and classified. Moreover, negations and tone in the sentence create a perplexity nature of sentiment analysis. To solve this problem, linguistic feature-based classification has been presented that utilizes a POS-based tagging in the attention layer and BOW to provide word embedding. Then, lemmatization and stemming process of words the root words are identified by maximum likeliness probability, resulting in the identification of new words with linguistic features. Furthermore, Naïve Bayes classifier and ensemble clustering with lambda function have been used to identify the negations and tone of the sentence. Thus, the results provided accurate detection of the positive, negative, or neutral sentiment of the sentence with a high accuracy of 96% and a precision of 97%.

Keywords: Deep attention network, Sentiment analysis, N-gram function, Parallel level fuzzy classifier, Naïve Bayes classifier, PoS-based tagging.

Nomenclature:

c	specific class
t	the text we want to classify
P(c) & P(t)	prior probabilities of this class and text
P(t | c)	probability the text appears in a given sentence
|D|	dataset size
d_i	ith document
TN	True Negative Value
FP	False Positive Value
FN	False Negative Value

1. Introduction

In a world of digitalization, millions of people are connected through World Wide Web and social networking (Kujur, et al., 2020) which allows a new way of sharing content with other users. Social Networks, E-commerce websites, blogs, etc. are different ways, which allow users to generate and share their content, ideas, and opinions with others easily, which leads to generating a huge amount of data every day (Tran, et al., 2021). Many business organizations need to study these opinions of the users and people rely on the feedback provided by various users on the web (Urena, et al., 2019) which can significantly affect the buying behavior of the product. Hence, analyzing the opinions or sentiments of the user emerges as an essential field to study (Rehman, et al., 2019). Most Search Engines, Android/IOS applications, Social Networking Platforms, and Government Websites are nowadays available in Indian Languages, and this generates a huge amount of data over the Internet which allows a researcher to explore the research field in Natural language processing for Indian languages (Shelke, et al., 2020).

Telugu is a Dravidian language that is indigenous to India. It is one of the few languages with official status in more than one Indian state, alongside Hindi, English, and Bengali. Within the states of Telangana and Andhra Pradesh, as well as the city of Yanam in Puducherry, it is the first language. The Government of India has designated one out of every six languages as a classical language of India. Telugu is the most widely spoken Dravidian dialect and ranks third in terms of native speakers in India (74 million, according to the 2001 census) (Badugu, et al., 2020). Hence it becomes necessary to analyze people's opinions, feelings, evaluations, appraisals, attitudes, and emotions regarding entities such as products, services, organizations, individuals, situations, events, themes, and their attributes (Kumar, et al., 2021) in Telugu language as well.

Natural language processing (NLP) is a field of computer science and artificial intelligence that studies how human and computer languages interact (Juhn, et al., 2020). Sentiment Analysis is the subfield of NLP that deals with the extraction of sentiment from a source of data. It tries to understand the data in human language and categorize it into positive, negative, and neutral sentiments. Sentimental analysis of Code-Mix social media data allows us to deduce the underlying sentiment of a word or sentence, which has a wide range of real-world applications (Joshi, et al., 2019). Sentiment analysis has been used in various applications like a product, event, or movie feedback. The accurate forecasting of sentiment analysis in the Indian movie based on the users' opinions in the microblog data helps these industries to earn more profit (Minaee, et al., 2019). Many existing methods have been applied to sentiment analysis and the standard methods like SVM, and random forest provide considerable performance (Saad, et al., 2019). Moreover, the NLP completed nicely in marketing evaluation, competitive analysis, and locating unsuccessful gossip for threat control in massive records surroundings. Sentiment analysis in NLP (Hasan, et al., 2019) is a complicated undertaking that distributes unstructured textual content and classifies it as both a wonderful, terrible, or impartial sentiment to explain the opinions, feelings, and attitudes present in a text or a fixed of textual content (Zhang, et al., 2019). Many researchers find numerous system studying models till the specification of sentiment price is a query mark (Yang, et al., 2019) because of one-of-a-kind unstructured dataset with distinctive languages (Chiranjeevi, et al., 2019) with numerous challenges in identifying tone, polarity, and negations. Hence need arises in the implementation of a technique to carry out sentiment analysis in the Telugu language.

The main contributions of this paper are as follows:

- The nature of the words has been identified using deep Attention Expression Analysis Technique with a parallel level fuzzy classifier.
- Linguistic Feature-based Classification with a POS-based tagging in the attention layer utilizing BOW with word embedding which utilizes Naïve Bayes classifier to identify the negations in the sentence and ensemble clustering to determine the tone of the sentence.

These techniques thus help in categorizing the nature of sentences and words with effective identification of tone, negations, and new words in the sentimental analysis of Telugu language.

The content of the paper is organized as follows: Section 2 presents the literature survey; the novel solutions are presented in Section 3; the implementation results and its comparison and conclusion are in Section 4 and Section 5 respectively.

2. Literature survey

Jonnalagadda et al (Jonnalagadda, et al., 2019) employed Telugu SentiWordNet and a Rule-Based Approach for Telugu sentiment analysis. SentiWordNet was used to obtain the sentiment, and the results were confirmed using ACTSA (Annotated Corpus for Telugu Sentiment Analysis), an annotated corpus data set. However, to enhance accuracy, the work must be examined using Bi-grams and Tri-grams.

In this paper, Garapati et al (Garapati, et al., 2019) employed a Rule-Based Approach to create SentiPhraseNet. SentiPhraseNet was used to obtain sentiment, and the results were confirmed using ACTSA, an annotated corpus data set. Furthermore, the approach's weaknesses can be mitigated by increasing the number of rules and dynamism.

Priya et al (Priya, et al., 2020) suggested a novel framework that was created specifically for sentiment analysis of text data in the Telugu language. To gather and analyze sentiment in tweeter data in the Telugu language, the suggested framework was merged with the word embedding model Word2Vec, a language translator, and deep learning methodologies such as Recurrent Neural Network and Naive Bayes algorithms. In terms of accuracy, precision, and specificity, the results are promising. Furthermore, new algorithms can be added to the suggested framework in the future, and the dataset size can be extended.

Kumar et al (Kumar, et al., 2019) used a Bi-directional Recurrent Neural Network (BRNN) to improve sentiment analysis performance in regional languages. The BRNN technique has the benefit of representing high and low resource texts in a shared space, and the sentiment is assessed using a similarity metric. Based on Twitter data, the suggested method is evaluated and compared to existing methods such as Random Forest and Support Vector Machine (SVM). The proposed method's future work will focus on employing appropriate text representation and optimization techniques to improve sentiment analysis performance.

Surya Chandra et al (Suryachandra, et al.) used a descriptive analysis approach to classify Telugu Amazon reviews in their study. The research is divided into three stages: pre-processing, classification, and semantic analysis. Sentiment analysis in Natural Language Processing (NLP) is a difficult task that deals with unstructured textual content and categorizes it as either positive, negative, or neutral. Sentiment analysis is a subset of text mining that attempts to explain the thoughts, sentiments, and attitudes expressed in a text or set of textual content. Cleaning the received data, performing missing value treatment, and isolating the essential data from the reviews are all part of the pre-processing stage. Using the suggested Adabooster classifier, semantic analysis is also performed to determine the users' sentiment ratings and the compound polarity of each review. The analysis of images will be part of future work.

V.K. Singh et al (2013) in their work developed aspect-level sentiment analysis of movie reviews, a new type of domain-specific feature-based algorithm. They used SentiWordNet based scheme with two different linguistic feature selections comprising of adjectives, adverbs, and verbs and n-gram feature extraction. Also, for each movie reviewed, they calculated document-level sentiment and compared the findings to those obtained using the Alchemy API. Moreover, practically most of the reviews have a mixture of positive and negative sentiments about different aspects which leads to false sentiment detection. It should be concentrated on future work.

From the survey, to enhance accuracy, the work must be examined using Bi-grams and Tri-grams, (Garapati, et al., 2019) the approach's weaknesses can be mitigated by increasing the number of rules and dynamism, (Priya, et al., 2020) new algorithms can be added to the suggested framework in the future, and the dataset size can be extended, for (Kumar, et al., 2019) employing appropriate text representation and optimization techniques to improve sentiment analysis performance and for [Suryachandra, Palli, et al.,]the analysis of images is required as a part of future work. (Singh, et al., 2013) A mixture of positive and negative sentiments should be concentrated in the future. Hence to overcome the above-mentioned issues a novel methodology has to be implemented.

3. Deep attention network with sentence level classification-based sentiment analysis in Telugu language

Sentiment analysis has tremendous importance in assisting decision-making in a variety of applications particularly in the extraction of sentiments from text. However, detecting implicit and explicit aspects is a critical factor in determining the sentence's contextual character, which has been overlooked in earlier studies. As a result, a novel Deep Attention Expression

Analysis Technique is presented which uses a Deep Attention Network with a parallel level fuzzy classifier to recognize the nature of the words in the sentence, and then the implicit as well as explicit nature of the sentence is identified and classified by sequential word N-gram functions Furthermore, negations and tone in the sentence make sentiment analysis more difficult. As a consequence, Linguistic Feature-based Classification has been proposed with a POS-based tagging in the attention layer using BOW with word embedding to tackle the problem. To identify the negations in the sentence, the Naive Bayes classifier is used to classify the presence of word ambiguity. The sentence's tone is also determined by connecting the words using ensemble clustering and the lambda function. Furthermore, via lemmatization and stemming to identify the inflection of root words, each word is normalized with maximum likeliness probability according to semantic aspects, resulting in the identification of new words with linguistic features. Finally, the sentiment nature of the sentence is obtained by classifying either positive, negative, or neutral depending on the polarity nature of the sentence using the deep attention network. Thus, the sentiment analysis of the selected sentence is efficiently identified by the proposed methodology without any perplexity considering the explicit and implicit nature, negations, and tone. The architecture of the proposed method is represented in Figure. 1.

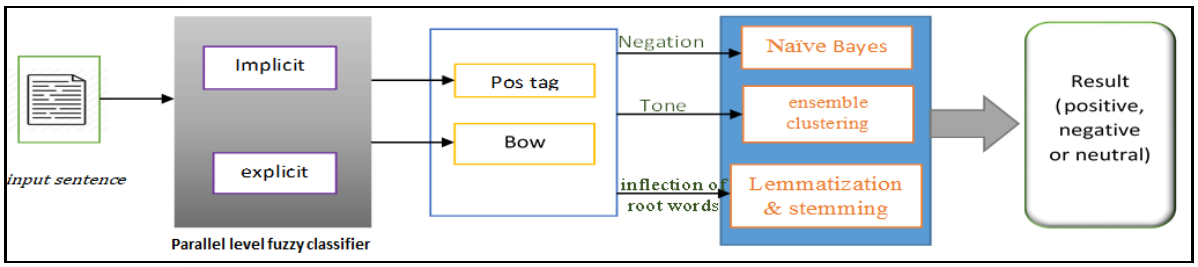


Fig. 1: Architecture of the proposed method

The input sentence is passed through a parallel level fuzzy classifier, which classifies the implicit and explicit nature of the sentence. Then to identify the tone of the sentence, the sentence is tagged with POS tagging. From the tagged sentence, the negation is identified by Naïve Bayes and tone classification is performed by ensemble clustering. Furthermore, root words were found by stemming and lemmatization. Then, the sentence is classified as either positive, negative, or neutral.

3.1 Deep attention expression analysis technique

In this technique, the implicit and explicit nature of the sentence is identified using Deep attention network with parallel fuzzy classifier and N gram functions. Before feeding data to a deep attention network, sentences have to be filtered to get a proper sentence for more effective analysis. In this process, the punctuations and stop words are avoided, and also the words that are present more than once in a sentence are omitted. Then, the preprocessed sentence was given to a deep attention network. The process flow of deep attention network is shown in the figure. 2,

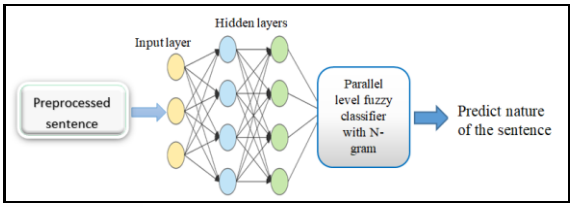


Fig. 2: Architecture of Deep Attention Network

The preprocessed sentence passed through deep attention network layers which process the sentence by ignoring some parts of the input sentence to focus on the desired words in the sentence. The deep attention layers were enabled to dynamically highlight relevant features of the input data, which is typically a sequence of textual elements. It is applied directly to the raw input or its higher-level representation. The attention layer computes a weight distribution on the input sequence by assigning higher values to more relevant elements. Then a parallel level fuzzy classifier was used to identify the nature of the sentence by using the Fuzzy Unordered Rule Induction algorithm (FURIA). Where the Fuzzy classifier groups the words into a fuzzy set with a membership function specified by truth value.

Algorithm 1: Implicit and explicit nature classification

Input: Collection of sentences {$S1$, $S2$, $S3$,...,}
Output: nature assigned to sentences
initialize nature
for all sentences **do**
stanford_tagger = SPOS(sentences$_i$) /∗ Applying Stanford Part-Of-Speech Tagger on each sentence ∗/
if NN in Stanford _tagger **then**
nature ← NN
end if
end for
initialize nature_groups
for all nature **do**
WordNet sets = WNSS(nature$_i$) /∗ Applying WordNet synonym set on each nature ∗/
if TRUE in WordNet_sets **then**
nature_groups ← nature$_i$
end if
end for
frequent_nature = frequency_measure (nature, nature_groups) /∗ Filtering the frequent nature ∗/
fuzzy_rules = FURIA (sentences, frequent _nature) /* Building Fuzzy rules */
initialize nature_assigned_sentences
for all sentences **do**
nature_identification = FURIA(sentences$_i$)/∗ Applying Fuzzy rules on each sentence ∗/
if TRUE in nature_identification **then**
nature_assigned_sentences ← nature_identification
end if
end for
return nature_assigned_sentences

Then the sequential word N-gram functions for sentence-level classification are used for the identification of the nature of the sentence.

A sequence of n objects in a text document, which comprises words, numbers, symbols, and punctuation are fed to N-gram models. The most frequent n sizes

are 2 (bigrams), 3 (trigrams), and 4(four grams). Considering an n-gram where the units are characters and text with t characters, where $t \in N$. There are $t - n + 1$ strings, where each string requires n units of space. Thus, the total space required for n-gram is $(t - n + 1) * n$ which is simplified in equation (1) as:

$$-n^2 + (t + 1)n \quad (1)$$

Thus, the implicit and explicit nature combined the sentence classified by N-gram function. However, the negations and tone in the sentence are avoided in N-gram function, and the original nature of the sentence is not classified perfectly. To solve this issue, further sentence classification is done by linguistic feature-based classification method.

3.2 Linguistic feature-based classification

In this Linguistic Feature-based Classification method, PoS (part of speech) tagging has been done in the attention layer with BoW (bag of words) word embedding which assigns a special label to each token (word) in a text corpus to denote the part of speech as well as other grammatical categories like tense, number (plural/singular), and so on. Then if any negations are present in the input sentence which is identified by the Naïve Bayes classifier, the tone was identified by using ensemble clustering with a lambda function that evaluates an expression for a given sentence. Linguistic features are identified by utilizing maximum likeliness probability according to the semantic features by lemmatization and stemming considering the inflection of root words. During the stemming process, it removes the last few characters of the word, and lemmatization process makes the dictionary form a word, then analyzes the word's nature.

The process flow of the Linguistic Feature-based Classification method is given in Figure 3,

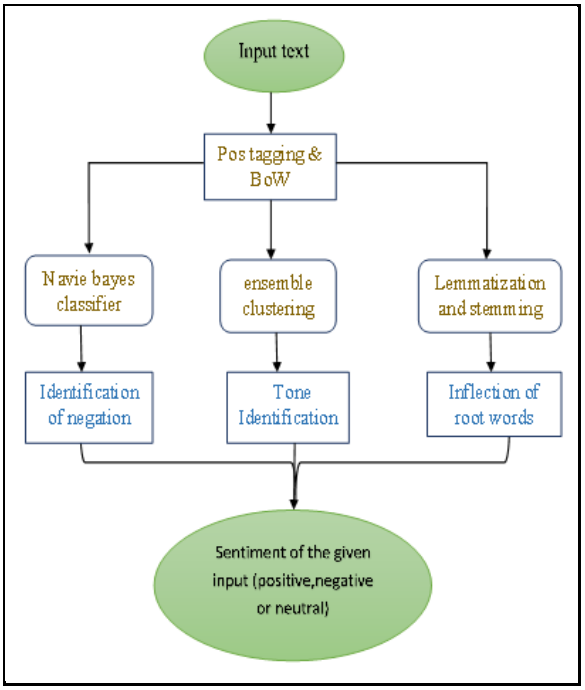


Fig. 3. Linguistic Feature-based Classification

Step 1:

Every word in a phrase is in correspondence with a particular part of speech, depending on the definition of the word and its context cataloged by part of speech (PoS) tagging which utilized BoW (bag of words) with word embedding. The PoS tagger assigns a tag to each word from BoW like JJ, JJS, VB, VBS, RB, NN, NNS, DT, etc., as shown in Table 1.

Table 1. PoS tags of the proposed system

PoS id	PoS name	PoS abbreviation
1	Noun	NN
2	Adjective	JJ
3	Verb	VB
4	Adverb	RB
5	Nouns	NNB
6	Adjectives	JJS
7	Verbs	VBS

From the tagged words naive Bayes classifier is used to determine the sequence of words in the sentence that is affected by negation words such as లేదు, కాదు which is shown in Figure 4.

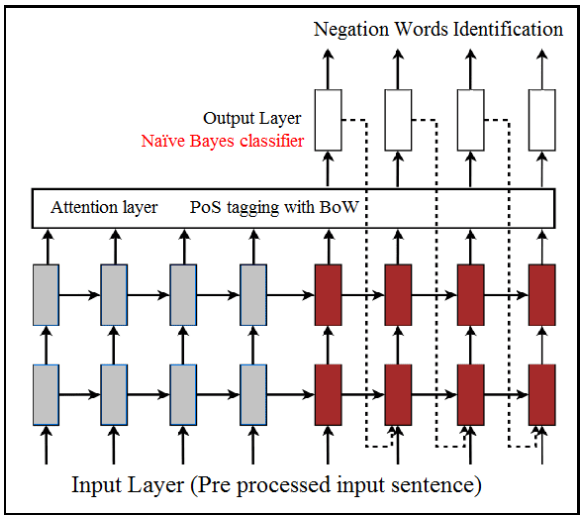


Fig. 4. Architecture of proposed negation identification

In multinomial Naive Bayes to find the probabilities of classes assigned in texts, joint probabilities of words and classes have been used. The Naive Bayes classifier assumes that the existence of one feature in a class is unrelated to the presence of any other characteristic in that class. Even though these characteristics are interdependent, they all contribute to the fact to be identified by Bayes Theorem, for a word t and a class c [22],

$$P(c|t) = \frac{P(c)P(t|c)}{P(t)} \quad (2)$$

In equation (2),

c is a specific class

t is a text we want to classify

$P(c)$ & $P(t)$ are the prior probabilities of this class and text. And

$P(t \mid c)$ is the probability the text appears in a given sentence.

In our method probability $P(c|t)$ which classifies the probability of word t occurs in class c to identify word negation in the sentence.

Step 2:

To identify the tone of the sentence correlating the words with ensemble clustering. In the group, similar words are obtained with a lambda function. The ensemble method correlates the word with a collection of words and it predicts the exact tone of the sentence.

In a review set R contain m number of reviews $\{r1, r2, \ldots rm\}$, then the tone classification process shown in fig. 5,

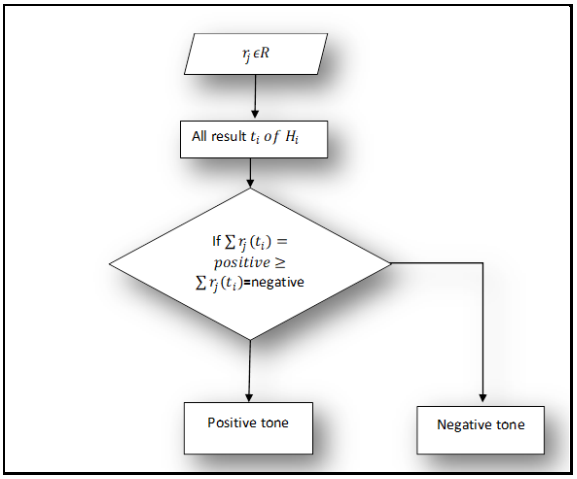


Fig. 5. Tone identification of sentence using ensemble method

Step 3:

The class prior probability is estimated as the Maximum Likelihood Estimate by following, [30]

$$P(C_k) = \frac{\sum_{i=1}^{|D|} P(C_k|d_i)}{|D|} \quad (3)$$

Where,

|D| is the dataset size

d_i is i[th] document

Lemmatization takes into account the context when converting a word to its meaning basic form as a Lemma. **Stemming sometimes results in stems that are not complete words so** lemmatization **was performed. For root word extraction,** lemmatization **was performed and the word was converted into a meaningful dictionary form.** Lemmatization and stemming processes have been shown in Figure. 6.

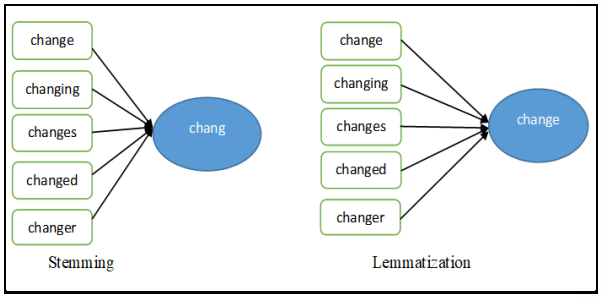


Fig. 6 Example of lemmatization and stemming

From Figure 6 in the stemming process, the words change, changing, changes, changed, and changer stemmed to chang. This word chang does not the root of the input word so that the words are lemmatized by the instance of the WordNetLemmatizer() and lemmatize() function on a single word. As a result, the

Linguistic Feature-based Classifier classified the given input sentence as positive, negative, or neutral.

Overall, the proposed deep attention network with sentence level classification based sentiment analysis considers linguistic features by utilizing the parallel level fuzzy classifier with N-gram function to find the implicit as well as explicit nature of the sentence. Also, the tone, negation, and root words were identified by naïve Bayes, ensemble clustering, Lemmatization, and stemming process by tagging the sentence with PoS tagging. Finally, the proposed method effectively analyzed the implicit and explicit nature, tone, as well as expression of the input sentence with polarity classification. The results obtained from deep attention network with sentence level classification-based sentiment analysis considering linguistic features were discussed in the next section.

4. Results and Discussion

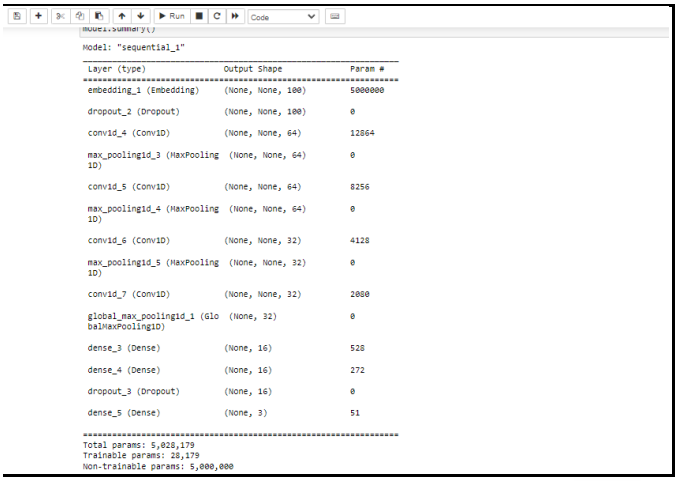
This segment provides a detailed description of the implementation results as well as the performance of the proposed system and a comparison section to ensure that the proposed system performs valuably.

4.1 Experimental Setup

This work has been implemented in the working platform of Python with the following system specification and the simulation results are discussed below.

4.2 Dataset Description

In this work, Annotated Corpus for Telugu Sentiment Analysis (ACTSA) [23]
dataset is used to detect the sentiment analysis in social media online platforms which contains 5457 Telugu sentences. Since ACTSA is the largest resource currently accessible that compiles Telugu sentences from many sources and then goes through pre-processing and hand annotation by Telugu speakers, it is chosen as the research dataset. In the proposed system dataset was split into a training set and test set, the proposed system used the training set to train the proposed model in which 80% of the dataset was assigned to the training set while 20% of the dataset was assigned a test set. The below diagram shows the training data set,

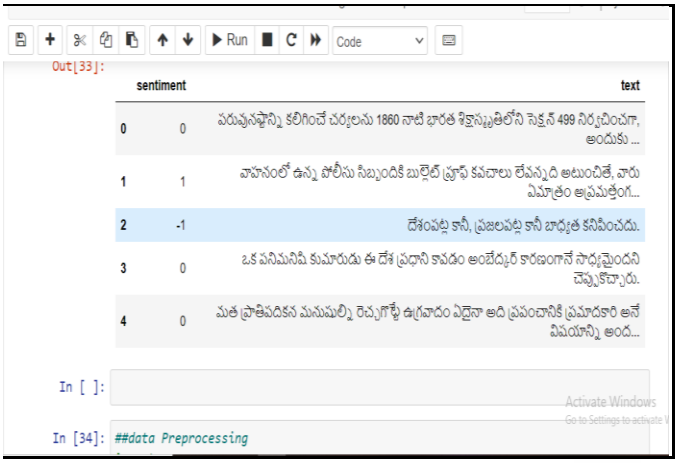


Model: "sequential_1"

Layer (type)	Output Shape	Param #
embedding_1 (Embedding)	(None, None, 100)	5000000
dropout_2 (Dropout)	(None, None, 100)	0
conv1d_4 (Conv1D)	(None, None, 64)	12864
max_pooling1d_3 (MaxPooling 1D)	(None, None, 64)	0
conv1d_5 (Conv1D)	(None, None, 64)	8256
max_pooling1d_4 (MaxPooling 1D)	(None, None, 64)	0
conv1d_6 (Conv1D)	(None, None, 32)	4128
max_pooling1d_5 (MaxPooling 1D)	(None, None, 32)	0
conv1d_7 (Conv1D)	(None, None, 32)	2080
global_max_pooling1d_1 (Glo balMaxPooling1D)	(None, 32)	0
dense_3 (Dense)	(None, 16)	528
dense_4 (Dense)	(None, 16)	272
dropout_3 (Dropout)	(None, 16)	0
dense_5 (Dense)	(None, 3)	51

Total params: 5,028,179
Trainable params: 28,179
Non-trainable params: 5,000,000

Fig. 7. Simulation view of a training data set



Out[33]:

	sentiment	text
0	0	పరువునష్టాన్ని కలిగించే చర్యలను 1860 నాటి భారత శిక్షాస్మృతిలోని సెక్షన్ 499 నిర్వచించగా, అందుకు ...
1	1	వాహనంలో ఉన్న పోలీసు సిబ్బందికి బుల్లెట్ ప్రూఫ్ కవచాలు లేవన్నది అటుంచితే, వారు ఏమాత్రం అప్రమత్తంగ...
2	-1	దేశంపట్ల కానీ, ప్రజలపట్ల కానీ బాధ్యత కనిపించదు.
3	0	ఒక పనిమనిషి కుమారుడు ఈ దేశ ప్రధాని కావడం అంబేద్కర్ కారణంగానే సాధ్యమైందని చెప్పుకొచ్చారు.
4	0	మత ప్రాతిపదికన మనుషుల్ని రెచ్చగొట్టే ఉగ్రవాదం ఏదైనా అది ప్రపంచానికి ప్రమాదకారి అనే విషయాన్ని అంద...

In [ ]:

In [34]: ##data Preprocessing

Fig. 8. Result of the proposed method

Figure. 8 After the preprocessing, the text messages are classified into three different types positive, negative, and neutral. In a deep attention network, a parallel-level fuzzy classifier divides the implicit and explicit nature of the sentence with a sequential N-gram function, which gives the result of the implicit and explicit nature of the sentence. Then linguistic features are analyzed by Pos tagging correlating with BoW. From the tagged set of data, negation words are identified by using the naïve Bayes classifier also the tone of the sentence is classified by the ensemble clustering with lambda function. Then to find the inflection of root words stemming the sentence lemmatization is done. Then extract data from the layer's deep attention network and linguistic feature-based classification the proposed dataset assigned the labels as, positive that is 1, negative that is -1, and neutral that is 0. The proposed system considers negation word, tone, and inflection of root words so

that the accuracy of the proposed method increases when compared to other existing systems.

4.3 Performance metrics of the proposed system

4.3.1 Accuracy

The accuracy of the input data is calculated using,

$$\text{Accuracy} = \left[\frac{TP+TN}{TP+TN+FP+FN}\right] \quad (4)$$

TP- True Positive Value
TN- True Negative Value
FP- False Positive Value
FN- False Negative Value

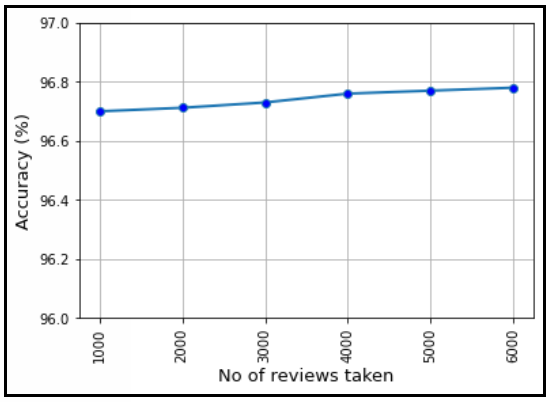


Fig. 9. Accuracy of the proposed System

The above-mentioned graph clearly explains the accuracy of the proposed system. From the graph, as the number of reviews is increased from 1000 to 6000 the proposed system's accuracy is also increased. The proposed system by using a deep attention network in which the perplexity is reduced by using the lambda function thereby increasing the accuracy of the proposed system from 96.70 to 96.79 with an increase in reviews.

4.3.2 Recall

The recall of the input data is calculated using,

$$\text{Recall} = \frac{TP}{TP+FN} \quad (5)$$

TP- True Positive Value
TN- True Negative Value

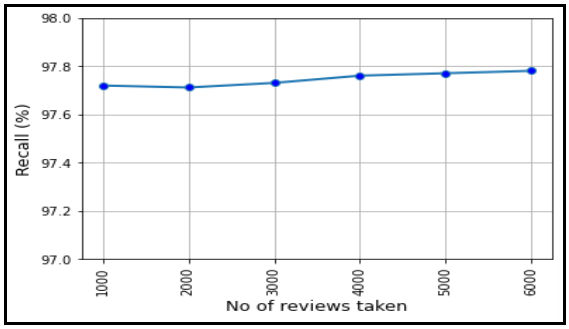


Fig. 10. Recall of the proposed System

Figure. 10 concludes that the number of reviews increases recall of the proposed system also increases. When the number of reviews taken is 1000 then recall is 97.70% and recall increases corresponding with the number of reviews increase. At the point of 6000 reviews recall is the maximum value of 97.79%. Due to the normalization of the word according to the semantic features by Lemmatization and stemming recall is increased in our proposed method.

4.3.3 Precision

The precision of the input data is calculated using,

$$\text{Precision} = \frac{TP}{TP+FP} \quad (6)$$

TP- True Positive Value
FP- False Positive Value

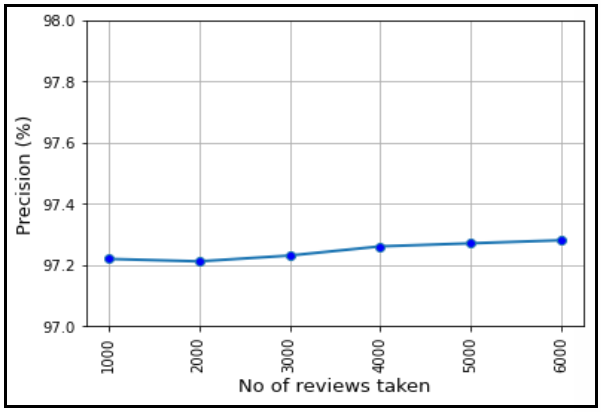


Fig. 11. The precision of the proposed System

The precision of the proposed system is shown in Figure 11. It shows the precision of the proposed system is increased when the number of reviews taken increases. When the number of reviews is 1000, 2000, 3000, 4000, 5000, or 6000 then the corresponding precision values are 97.21%, 97.21%, 97.23%, 97.25%, 97.27%, 97.30% respectively. consideration of negation and tone of the sentence by using the naïve Bayes classifier increases the precision value of our proposed method.

4.3.4 F1-Score

The F1-Score of the input data is calculated using,

$$F1=2*\frac{Precision*Recall}{Precision+Recall} \quad (7)$$

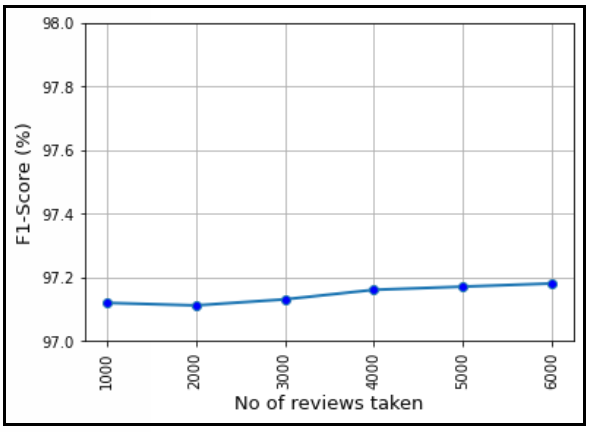


Fig. 12. F1 score of the proposed System

From Figure 12 when we increase the number of reviews from 1000 to 6000 also F1-score increases from 97.1% to 97.19%. From the graph, the number of reviews is increased as well and the proposed system f1 score is also increased in which the deep attention network incorporates a parallel level fuzzy classifier with sequential N-gram function. The overall performance of our system is given in Fig. 13,

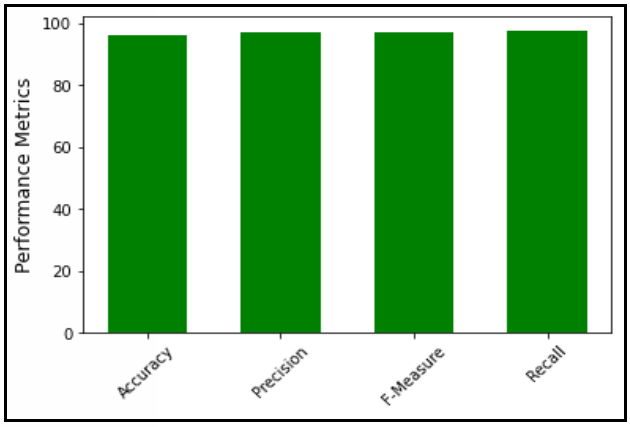


Fig. 13. Overall performance of the proposed System

4.4 Performance comparison of the proposed method:

This section describes the various performances of the proposed method compared with the results of previous methodologies like MNB+LSTM, naïve Bayes, SVM, Random forest, stacking, Ada-boost.

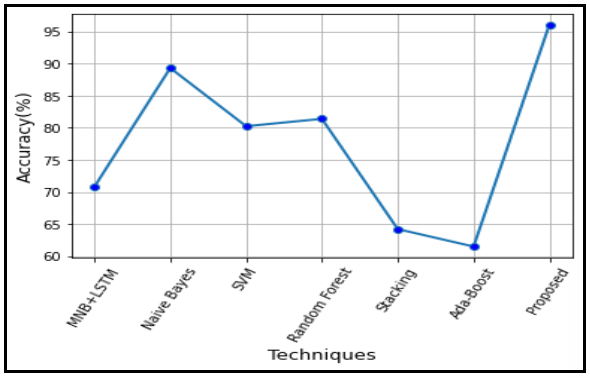


Fig. 14. Accuracy comparison of the proposed System

Figure. 14 shows the accuracy of our proposed system is 96% which is higher than the other methods that are taken for comparison. The accuracy of MNB+LSTM [27], naïve Bayes [25], SVM [28], Random forest [24], stacking [29], Ada-boost [26] are 71%, 89%, 80%, 82%, 64%, 61% respectively. This clearly shows that our proposed system was performed better than other methods.

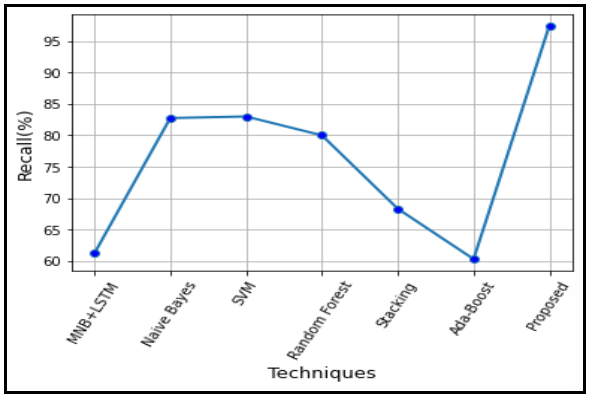


Fig. 15. Recall comparison of the proposed System

When recall is compared to the existing systems such MNB+LSTM, naïve Bayes, SVM, Random forest, stacking, Ada-boost the proposed system recall is higher than the existing systems as shown in fig. 15. The proposed recall is 98% highest when compared with the recall of other existing techniques. Recall percentages of existing systems like MNB+LSTM, naïve Bayes, SVM, Random forest, stacking, and Ada-boost are 61%, 83%, 83%, 80%, 67%, and 60%. Hence the proposed system has the highest value of 98% than other methods.

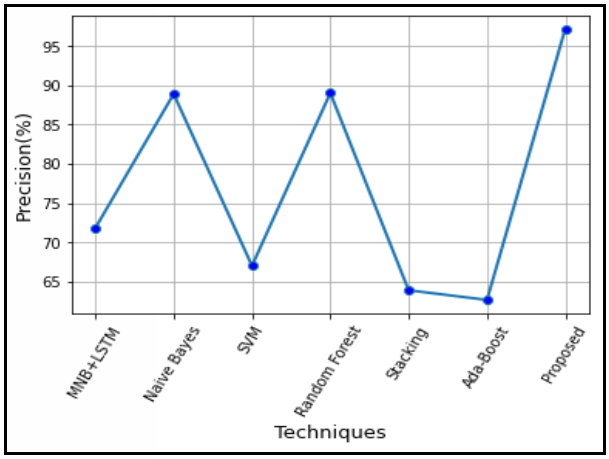


Fig. 16. Precision comparison of the proposed System

Precision comparison of the proposed system is shown in Figure 16. The precision value of MNB+LSTM is 72%, The precision value of naïve Bayes is 88%, The precision value of SVM is 63%, The precision value of Random forest is 88%, The precision value of stacking is 64%, The precision value of Ada-boost is 62%. When it comes to the proposed system precision value reaches a maximum of 97%. This shows that the proposed method performed better compared to other methods.

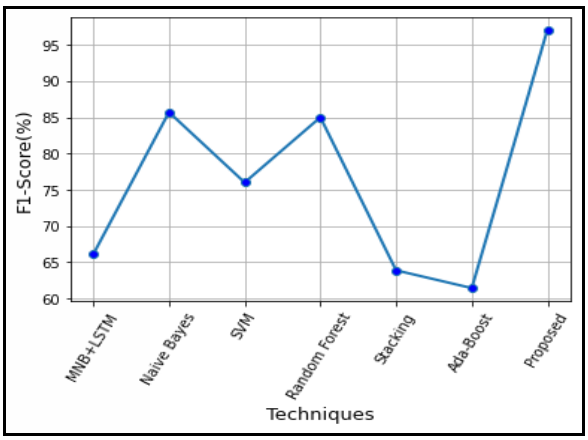


Fig. 17. F1-score comparison of the proposed System

The above figure. 17 shows the F1-score comparison of the proposed system. When a proposed method has a value of 97%, other comparison methods have the lowest value than the proposed system. Corresponding values for MNB+LSTM, naïve Bayes, SVM, Random forest, stacking, and Ada-boost methods are as follows 66%, 86%, 76%, 85%, 64%, 61%. These values are lower than the proposed value of 97%. This proves that the proposed system has better performance.

Overall, the proposed sentiment analysis technic outperforms existing methods like MNB+LSTM, naïve Bayes, SVM, Random forest, stacking, Ada-boost. The proposed method achieved an accuracy of 96% using deep attention analysis technique with linguistic feature-based classification by considering tone, negation, and root words.

5. Conclusion

Finding annotated Telugu datasets for NLP applications such as POS tagging and sentiment analysis is difficult. Hence in this work classification of sentiment was analyzed with a deep attention network which determines the implicit and explicit future of the sentence by parallel-level fuzzy classifier and N-gram function. Also, linguistic feature-based classification used to identify the negation, tone, and root words is identified and classified by using naïve bays classifier, ensemble clustering, lemmatization, and stemming. Finally, the extracted value from the attention network and linguistic classification proposed system classified as positive, negative, or neutral with an accuracy of 96% with a system precision of 97%. The recall of the approach is increased by 98%, with a 97% F1-score, and also depicted enhanced performances comparatively with other existing approaches.

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Investigating feature extraction techniques for imbalanced time-series data

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Abstract

High-class data imbalance is usually present in many applications, such as fraud detection and cancer diagnosis, hence effective classification with time-series data is an essential topic of study. Furthermore, excessively imbalanced data presents a challenge, since most learners will be biased toward the majority group, and in extreme circumstances, will overlook the minority group completely. Over the previous two decades, fundamental methodologies have been used to study class imbalance in depth. Despite recent breakthroughs in addressing data imbalance with feature extraction and its growing popularity, there is relatively little empirical work in the domain of feature extraction with time-series-based class imbalance. Following record-breaking performance outcomes in various complicated domains, researchers are now looking into the usage of feature extraction approaches for issues with significant degrees of class imbalance. To better understand the effectiveness of feature extraction when applied to class-imbalanced data, available research on class imbalance, feature extraction, and fundamental approaches like SMOTE, Resampling, and others are examined. This study explores the specifics of each study's execution and experimental outcomes, as well as provides more insight into its advantages and limitations. We discovered that there is relatively limited study in this field. Several classic approaches for class imbalance, such as data sampling and SMOTE, work with feature extraction, but more sophisticated methods that take the use of minority class feature learning abilities have potential applications. The survey continues with a discussion that identifies numerous gaps in time-series data based on class-imbalanced data to improve future studies.

Keywords: Big Data, Time Series, Machine Learning, Feature Extraction.

1. Introduction

In any domain, 'time' is the most important concept. We use the time component to plot our revenue figures, income, bottom line, and economic expansion, and even predict outcomes and estimates (Fulcher and Jones, 2017). Time series data, often referred to as time-stamped data, is a representation of the data elements that are classified in time sequence. The data which has been timestamped was collected at different points in time. Such time stamps are often made up of many data measured within the same sources over a length of time which are used to monitor variability. Because time is a component of everything observable, time series data may be found everywhere. Time series data has long been related to financial applications. Time series data is becoming more prevalent due to the increasing instrumentation of our environment (He et al., 2015). Time series analysis (TSA) is essential in understanding how variables change over time and can be applied in various sectors such as finance, retailing, academics, and meteorology (Joo, & Jeong 2019; Yang et al., 2021). TSA is often used to study non-stationary data and is useful for cluster analysis, classification, fault diagnosis, and prediction in data analysis, analytical thinking, and deep learning, as presented in Figure 1:

- TSA is used for segmentation, classifying, intrusion detection, and making predictions in

information retrieval, pattern classification, and deep learning.

- In signal analysis, industrial engineering, and information science, time series is used for signal classification and estimate.
- In statistical, inferential statistics, quantification economics, earthquake engineering, meteorological department, and geology, TSA is used for predicting.

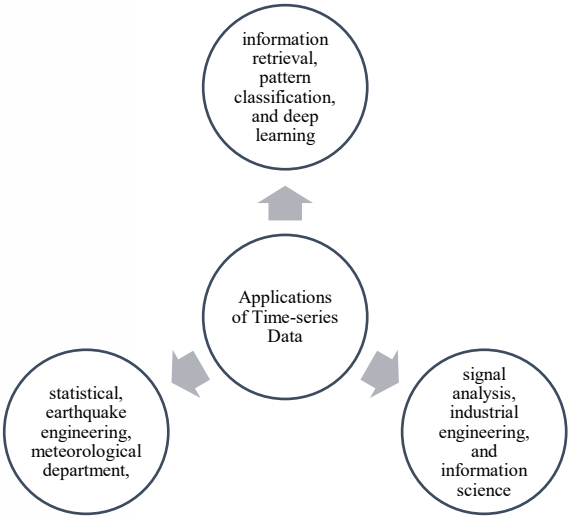

Fig.1. Application Areas of Time-Series Data

As a result, this might be a complicated issue to comprehend. When dealing with time-sensitive information, we must consider a great deal of detail in time series data (Li et al., 2018; Singh & Yassine, 2018; Shih et al., 2018; Cao et al., 2019). Existing time series forecasting methods are unquestionably effective in most circumstances, but they do have certain drawbacks. When provided merely the time component and the target variable, data scientists struggle to map their data. TSA often needs a wide range of data points in terms to maintain consistency and reliability. A big data set ensures that the sample group is representative, facilitating analytics that effectively reduces data redundancy. It also guarantees that any trends or patterns observed are not outliers and that seasonal volatility is considered (Shahriar et al., 2014; Wu & Liu 2018). This is when time series feature extraction engineering comes into play. This can turn a strong time series model into a great forecasting model.

To summarize, time-series data can be useful for classification in various domains, while imbalanced data can occur frequently in many situations. The presence of class imbalance should be considered when using time-series data for classification. Different techniques can be employed to address the class imbalance, such as resampling, cost-sensitive learning, and ensemble methods, depending on the nature of the data and the goals of the classification task.

Therefore, the purpose of this research is to meticulously examine and analyze feature extraction strategies applicable to imbalanced time-series data. Imbalances in classification data are pervasive and critical in fields like fraud detection, healthcare, and finance, often leading to models overlooking rare, yet important, events. Given that rare events, albeit infrequent, can have significant implications, the study seeks to illuminate effective methodologies to enhance the accuracy and reliability of classification models dealing with imbalanced datasets. Through a comparative analysis of various techniques, including PCA, SVD, Autoencoders, and ICA, the research aims to offer valuable insights and a foundation for the development or enhancement of algorithms that can adeptly navigate through the challenges posed by imbalanced time-series data, thereby supporting improved outcomes in detection and prediction tasks across various domains. The study also intends to identify gaps in the current literature and suggest directions for future research to advance understanding and solutions for class imbalances in time-series data.

2. Data Imbalance

A balanced dataset has an equal distribution of the target class, while an imbalanced dataset has an unequal distribution of observations where one class label has a large number of observations and the other has a small number, as in Fig 2. There are several cases in which the positive classes appear less often, such as illness diagnosis (Manogaran et al., 2019), fraud detection (Zhou, et al., 2021), computer security (Zhang et al., 2019), and picture recognition, which naturally produces skewed data distributions. Intrinsic imbalance is generated by naturally occurring data levels, particularly ones seen in clinical diagnosis where the proportion of persons is normal. Extrinsic imbalance, on the other hand, is caused by elements outside of the control of the researcher, such as collecting or storage processes (Huang et al., 2021). Supervised learning requires a training dataset with labelled samples for classification problems.

Class imbalance occurs when one class has significantly less data than another class in a binary classification problem (Krawczyk B 2016; Sun. 2011). (Often, the minority class (positive class) is the focus of attention in such cases, such as in diagnostic

imaging for disease recognition when the number of patients is limited. The majority of healthy individuals are known as negative samples in this case. Learning from these skewed datasets may be challenging, particularly when dealing with large amounts of data, and non-traditional machine learning approaches are sometimes necessary to produce good results. Because imbalanced data appears in many real-world applications, a detailed grasp of the class imbalance issue and the solutions available to remedy it is essential. This is seen in Fig. 3. The acquired information becomes meaningless and worthless if data mining algorithms are unable to categorize minority cases such as medical diagnoses of disease or abnormal products of inspection data.

This issue has recently been identified in a significant variety of real-world contexts (Zhang et al., 2022). Since the positive class has a larger probability value, learners are most prone to overclassify that when there's a class imbalance in data sets. As a result, patients from the negative class are more likely to be misidentified than cases from the positive class (Narwane & Sawarkar 2022).

Negative consequences arise from imbalanced datasets, making it challenging to accurately predict class labels. Traditional assessment criteria like accuracy can be misleading, as a naïve learner who always predicts the minority class can achieve high accuracy on a dataset with a small number of minority class samples. To overcome these issues, various classic machine-learning algorithms have been developed over the years.

To address class imbalance in machine learning, there are three types of methodologies: data-level strategies, algorithm-level methods, and hybrid approaches. Data-level strategies aim to reduce class imbalance through various data sampling approaches. Algorithm-level methods adjust the basic learners or their outcomes to reduce bias toward the dominant group, often using a weight or cost schema (Leevy et al., 2018).

Hybrid approaches (Bedi & Jindal 2021) intelligently combine data-level and algorithm-level methods. The main challenge with predicting from imbalanced datasets is accuracy, as classifiers may become biased towards the majority class. The confusion matrix displays how well the model classifies target classes, and it is used to calculate the model's accuracy in such cases.

Table 1 depicts the degree of disparity between the majority and minority classes. Imbalanced data sets are present in a broad range of classification issues that we meet in everyday banking, such as churn prediction and fraud detection. Quite often, we are confronted with severe circumstances in which the minority class fraction ranges between 0.1 and 0.2 percent. Fields such as fraud detection and anomaly detection are in critical condition. When it comes to medical diagnostics, signal errors are in a medium stage, which is straightforward to deal with.

Table 1. Degree of Imbalance

Degree of Imbalance	Proportion of the majority class	The proportion of minority class
Mild	80-60 %	20-40 %
Medium	99- 80%	1-20 %
Extreme	More than 99%	Less than 1 %

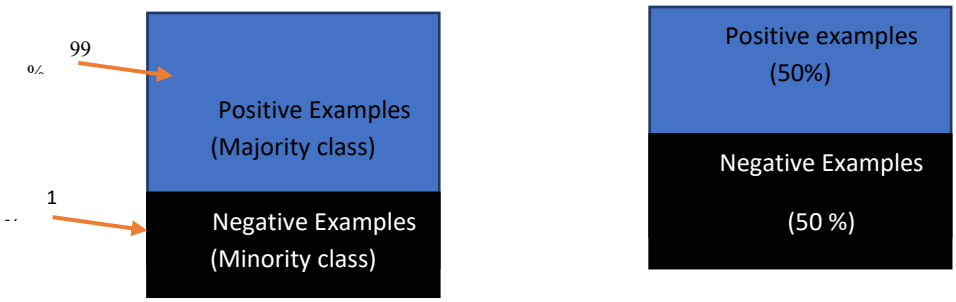

Fig. 2. Imbalanced and balanced dataset

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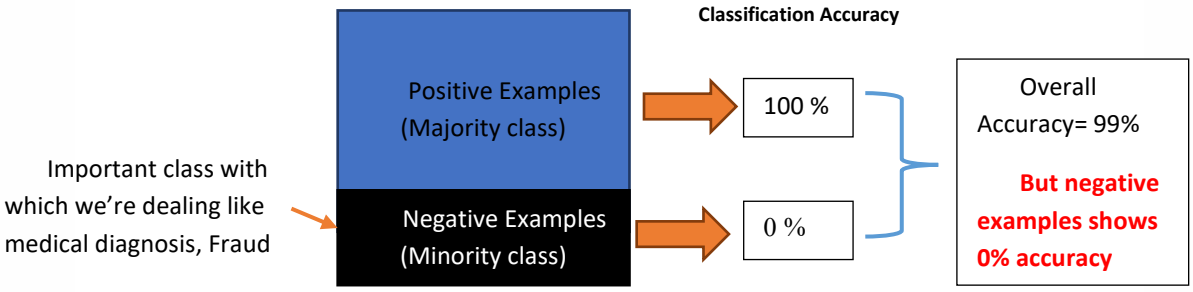

Fig. 3. Example of the class imbalance problem

3. Basic categories and challenges in data imbalance

In uncommon situations like fraud detection or illness prediction, it is crucial to accurately identify minority groups. The model should not be biased towards detecting just the dominant class but also give the minority class similar weight or relevance. Various strategies can be used to address this issue, and there is no one-size-fits-all approach to dealing with data imbalance. Each strategy performs effectively in different situations and has its own set of drawbacks.

3.1 Resampling (Oversampling and Undersampling)

The method described involves sampling a dataset to address class imbalance. Oversampling can be used to increase the number of instances in the minority class, while under-sampling can decrease the number of instances in the majority class. This can help create a balanced dataset where the classifier can treat both classes equally (Malhotra & Jain 2022; Mohammed et al., 2020). Figure 4 may provide additional illustration.

Rathpisey and Adji (2019) used resampling techniques to address the class imbalance in a hate-speech dataset, resulting in improved accuracy and effectiveness of SVM, Logistic Regression, and Naïve-Bayes models. Logistic Regression with Random Oversampling (ROS) had the highest F-1 Score of 95%. In (Lee and Kim, 2020), oversampling was used to address the imbalance in nuclear receptor profiles for deep learning predictions, resulting in a sensitivity and specificity of 71.4% and 78.7% and an accuracy rate of 82.9%, with an ROC-AUC of 0.822 using simple resampling techniques.

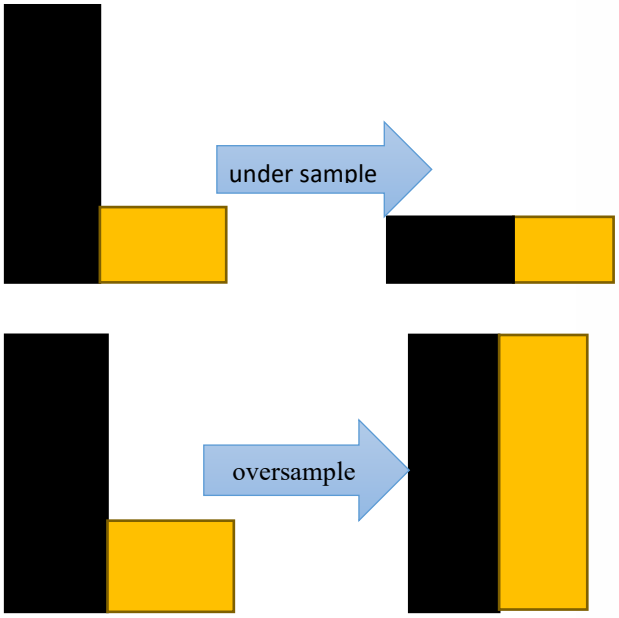

Fig.4. Under Sampling and Over-Sampling

3.2 SMOTE

SMOTE is a method of oversampling the minority class that generates new instances by using k closest neighbors to construct synthetic instances in feature space. This helps to avoid adding duplicate minority class entries to a model. Figure 5 illustrates how SMOTE generates new instances from existing data by selecting random nearest neighbors of minority class instances and creating synthetic instances in between them (Maldonado et al., 2022).

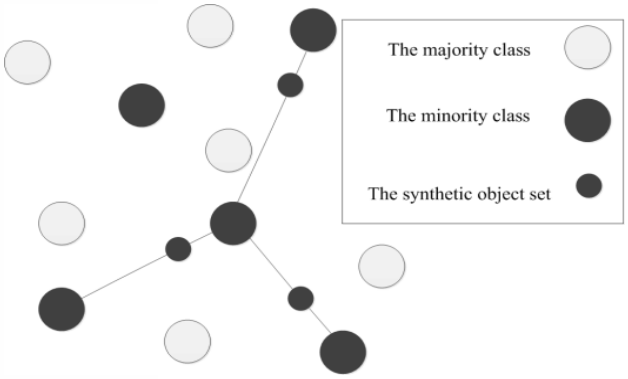

Fig.5. Basics of SMOTE Algorithm (Maldonado et al., 2022)

Rupapara et al., (2021) proposed an ensemble technique called RVVC, which combines logistic regression and support vector classifiers under soft voting rules, to detect hazardous remarks on social media networks. The performance of RVVC is evaluated on both imbalanced and balanced datasets using various evaluation metrics. The synthetic minority oversampling method (SMOTE) is used to achieve data balance on the imbalanced dataset. When TF-IDF features are employed with the SMOTE balanced dataset, RVVC outperforms all other individual models and achieves an accuracy of 0.97.

Satriaji and Kusumaningrum (2018) used the SMOTE approach with NB, SVM, and LR classifiers to balance the class distribution in a dataset. The study found that using SMOTE improved system effectiveness, particularly in imbalanced datasets, resulting in a 12% performance increase. The g-Mean score was 81.68%, with TP at 79.89% and TF-IDF at 79.31%. Among the classifiers, LR achieved the highest average score of 81.55%, followed by SVM at 81.55% and NB at 77.68%.

Pandey et al. (2019) presented an 11-layer deep-CNN mode employing SMOTE for categorizing the arrhythmias data into five classifications, per the ANSI–AAMI guidelines. The suggested novel approach has the major advantage of reducing the number of classifiers and eliminating the need to detect and divide QRS complexities. The experimental outcomes reveal that the developed Classification algorithm has better results in terms of accuracy, recall, F-1 score, and overall accuracy when compared to previous work in the research. These findings also show that the 70:30 train-test data set has the greatest performance accuracy of 98.30%.

3.3 Balanced bagging classifier

To address the issue of imbalanced datasets, a Balanced Bagging Classifier has been introduced. This classifier is similar to a traditional classifier but includes a step to balance the training set using a specific sampler during the fit. The "sampling strategy" and "replacement" parameters are used to determine the type of resampling required and whether or not to use sampling with replacement. By balancing the training set, the Balanced Bagging Classifier can help prevent the model from favoring the majority class due to its larger volume.

Ning et al. (2022), a new approach called balancing evolution semi-stacking (BESS) is proposed for sickness detection using partially labeled imbalance (PLI) data. The strategy addresses the issue of class imbalance by utilizing unsupervised learning through the BESS co-training methodology. The approach combines the information and classification diversity obtained through BESS to improve the effectiveness of the stacked ensemble. The approach is evaluated using PLI tongue image data, and the results show that BESS outperforms other state-of-the-art methods in identifying diabetic diabetes, chronic kidney illness, prostate cancer, and persistent ulcers. The statistical analysis of the results demonstrates the superiority and effectiveness of the proposed algorithm.

Table 2. The comparison between Resampling, SMOTE, and Balanced Bagging Classifier to Deal with Data Imbalance

Technique	References	Result	Advantages	Limitations
Resampling	Rathpisey and Adji (2019)	Accuracy= 91 % F1-Score= 95 %	Increase the duration of the run Reduce the amount of training data samples when the training data set is large to help with storage issues. Outperforms under sampling	Because it repeats minority class occurrences, it raises the chance of over-fitting. It can eliminate potentially helpful information that might be beneficial in the development of rule classifiers. The sample
	Lee and Kim (2020)	Sensitivity= 71.4 % specificity= 78.7 % accuracy= 82.9 %		

		and a ROC-AUC of 0.822		picked at random under-sampling might be skewed.
SMOTE	Rupapara et al., (2021)	Accuracy= 97 %	Synthetic examples are created rather than a replication of real instances, which mitigates the issue of over-fitting induced by random oversampling. There's no loss of important data.	SMOTE doesn't explore surrounding samples from different classes when producing synthesized examples. This may lead to an increase in class overlap and the introduction of extra noise. Doesn't take into account the importance of crucial traits.
	Satriaji and Kusumaningrum (2018)	G-mean = 81.68 %		
	Pandey et al., (2019)	Accuracy= 98.3 %		
Balanced Bagging Classifier	Ning et al. (2022)	The results of the trials support the suggested system's effectiveness and efficacy.	Reduces the noise Increase minor class examples to balance	Overfitting Costly

Figure 6 shows the accuracy comparison of different techniques reviewed in the literature. The accuracy of SMOTE is maximum discussed in (Rupapara et al., 2021; Pandey et al., 2019). However, it is clear that with different classifiers used the accuracy can be varied. Rupapara et al. (2021) the accuracy is maximum i.e., 98.30%.

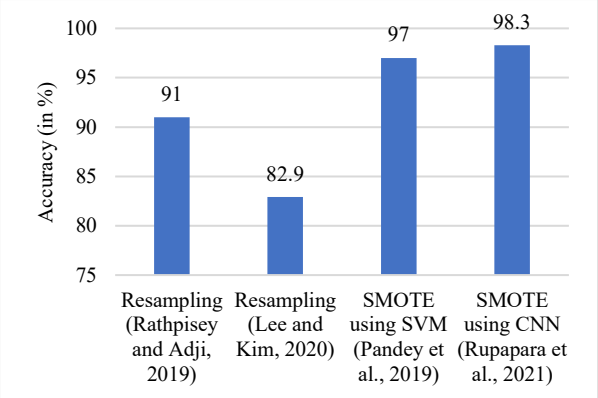

Fig. 6. The Accuracy Comparison of Different Techniques Reviewed

4. Feature extraction-based models to deal with data imbalance

Feature extraction is another technique to cope with dimensionality. Dimensionality reduction, which converts data into a low-dimensional space, is linked to feature extraction. It is important to note, however, that feature selection approaches are not the same as feature extraction techniques. Feature extraction uses functional mapping to build new features from the original data, while feature selection only returns a subset of the original features. For unstructured data such as photos, text, and audio, feature extraction techniques are more often used (Braytee et al.2016). Following are the types of feature extraction techniques discussed for our literature considering time-series data imbalance:

4.1 PCA

PCA (principal component analysis) is a method for emphasizing variance and highlighting significant patterns in a dataset. Principal Component Analysis (PCA) is a machine learning method for reducing dimensions in AI. It is a quantitative approach that transforms data of correlation qualities into a set of linear uncorrelated data via orthogonal conversion. The substantially altered qualities are the principal component. It's among the most popular data exploration and computational modelling packages. It's a technique used to extract significantly dominant points, areas, and features from a batch of data by reducing variance. When working with time-series data, it's often utilized to make data easier to understand and display.

Liu et al., (2018) concentrate on ICU death predictions, which is a frequent instance of ICU big data's secondary usage. Individual ICU death predictions are challenging for a variety of reasons, including large data, unbalanced distribution, and chronological synchronization. To discover the optimal predictor, many methods were studied, and various

AUC results were assessed in a large and important benchmark dataset. The recommended strategy surpassed the traditional machine learning approach, with SVM getting the best AUC value of 77.18%. This research establishes a framework for addressing comparable issues with large health data and aids in the promotion of healthcare services.

Abdulhammed et al. (2019) proposed using Principal Component Analysis (PCA) to reduce the dimensionality of features in the Intrusion Detection Systems (IDS) design. They showed that using low-dimensional features resulted in improved performance in terms of Detection Rate, F-Measure, False Alarm Rate, and Accuracy in binary and multi-class classification. They were able to reduce the feature dimensions of the CICIDS2017 dataset from 81 to 10 using PCA while maintaining a high accuracy of 99.6% in both multi-class and binary classification.

Hamed, et al. (2015) proposed a PCA-based technique to handle imbalanced activity data from sensor readings. A different classifier, LDA+WSVM, is utilized to address this issue. The performance of the proposed method is compared with other methods using multiple real-world datasets, and the results show that LDA+WSVM achieved a higher recognition rate. The recall, precision, F-score, and accuracy of the proposed method are reported to be 77%, 78.4%, 77.7%, and 93.5%, respectively.

4.2 Singular value decomposition

Similar to principal component analysis, SVD is a data decomposition method (PCA). It is used in signal processing and statistics for a variety of tasks, including signal feature extraction, matrix approximation, and pattern identification (Chang et al.2012).

SVD exists and is unique up to the signs for any matrix X (m by n). For the data matrix X, the singular value decomposition is:

$$X = UDV^t \quad (1)$$

Where, U, V= Left and Right Singular Vector, D= singular vectors' diagonal

The choice of a small number (k) of additional features is based on criteria for the proportion of initial data variation accounted by the new features (usually 80-90 percent). In these extra features, every one of the original features has indeed been evaluated. SVD could be used straight for feature extraction since the additional features (columns of U) integrate the old features (columns of X). Uses rank constraints on the SVD to ensure that each new primary coordinate has a minimal number of nonnegative. This will result in the extraction of original characteristics as well as their meaning (Modarresi, 2015).

To address this challenge, Chen, et al. (2008) proposed a unique paradigm termed the "Information Granulation Based Data Mining Approach." Information Granules, rather than numerical data, are used to gain knowledge in the suggested approach, which mimics the human capacity to digest information. Experiments demonstrate that strategy can considerably improve the ability to categorize data that is skewed. The proposed method's overall accuracy and G-mean are 0.973 and 0.948 respectively. Hossain & Rab, (2022) proposed a novel approach involving SVD and a modified ensemble classifier that outperformed the extreme learning machine (ELM) with macro-F1 scores of 90.78 percent. All of the deep learning techniques outperformed these benchmarks. The ensemble classifier excelled on the Reuters dataset, with an accuracy of 91.49 percent. They created four datasets with varying degrees of imbalance to experiment. A modified ensemble classifier based on the results was also given, which can classify both imbalanced and balanced data.

4.3 Autoencoder

An autoencoder, a kind of NN, could be used to generate a condensed version of raw input. Figure 7 depicts the encoding and decoding sub-models that make up an auto-encoder. The encoding block compresses the data, and the decoding block attempts to rebuild it from the encoding block's compressed form. Throughout the training, the encoding model is preserved, but the decoding model is removed. After that, the encoding could be used as a data method of preparation to extract features from the data to train a new ML model.

The suggested DlapAE method with Laplacian regularization in (Zhao et al.2020) may enhance this fault diagnostic framework's generalization performance and make it more suited for feature learning and classification of imbalanced data. Last but not least, two examples of experimental bearing systems may be used to demonstrate the efficacy of the suggested technique. In comparison to previous deep learning-based fault diagnosis approaches, the suggested fault diagnostic method can successfully execute accurate fault detection for balanced and imbalanced rotating machinery datasets. The proposed

approach is 99.4% accurate and has a standard deviation of 0.2514. The dataset has a recognition accuracy of 96.94%, while the standard deviation in the 10 trials is 1.7%.

Alhassan et al. (2019) used a prediction-based DL method to help in the assessment of individual overall mortality in healthcare. The Stacked Denoised AE was trained on an intrinsically unbalanced time-stamped database. Different computational intelligence algorithms that employ various data balancing methodologies are compared with the performance. The suggested model, which surpasses typical DL algorithms with an accuracy of 0.7713, intends to solve the issue of imbalanced data.

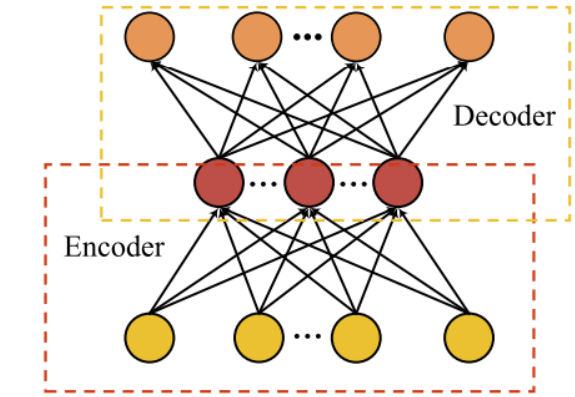

Fig. 7. Diagram of Autoencoder

Wong et al. (2020) proposed two cost-sensitive algorithms to solve the class imbalance issue: Cost-Sensitive Deep Neural Networks (CSDNN) and Cost-Sensitive Deep Neural Network Ensembles (CSDE). CSDNN is a variant of Stacked Denoising Autoencoders, while CSDE is the ensemble learning version of CSDNN. The proposed approaches are evaluated using six real-life datasets in diverse business areas. The results demonstrate that the suggested approaches work well in handling class imbalance problems and outperform all other methods tested. The performance metrics used are TPR, AUC, and G-mean, and the cost-sensitive learning algorithms AdaCost, CSDNN, and MetaCost reach 0.64, 0.58, and 0.52, respectively.

4.4 ICA

ICA (Independent Component Analysis): ICA is a continuous dimension reduction technology that takes a set of non-dependent components as input and seeks to correctly identify each one while eliminating any non-useful noise. Two input characteristics are said to be non-dependent when their linear and nonlinear dependencies are equal to zero. Independent Component Analyses are widely used in medical applications such as EEG and MRI evaluation to identify significant data from unproductive ones.

On a limited and imbalanced fMRI dataset from a word-scene memory challenge, Wang, et al. (2020) presented a three-step technique. Convolution-GRU for time series-imbalance dataset, and also Independent Component Analysis was used. The suggested technique has a 72.2 percent accuracy, which increases classification performance. The findings reveal that the suggested approaches work well in dealing with class imbalance problems and outperform all other methods tested.

Yang et al. (2021) built a novel two-channel hybrid CNN for automatic ECG recognition utilizing time series imbalanced data using ICA, with an accuracy of 0.9554 for identifying normal, CHF, and CAD individuals using leave-one-out cross-validation. Tests with multi-level noisy and unbalanced data yielded similarly excellent results. As a result, the suggested approach can identify coronary artery disease (CAD) and congestive heart failure (CHF) in clinical settings.

Table 3. The Comparison Between Different Feature Extraction Techniques

Technique	References	Result	Advantages	Disadvantages
PCA	Liu et al. (2018)	AUC performance of 0.7718 is achieved	Every new main dimension should have a restricted number of nonzero factors. Correlated Features are removed. Enhances the Algorithm Overfitting is reduced as a result of performance.	Information Loss Data standardization is a must before PCA Independent variables become less interpretable
	Abdulhammed et al., (2019)	high accuracy of 99.6%		
	Abidine et al. (2015)	Recall= 77 % F-score= 78.4 % Accuracy= 78.4 %		
SVD	Chen et al. (2008)	Accuracy= 97.33 % % G-Mean = 94.83 % %	Simplifies data removes noise may improve algorithm results	Transformed data may be difficult to understand information loss
	Hossain et al. (2022)	F-1 Score= 90.78 % Accuracy= 71.449 %		

Autoencoder	Zhao et al. (2019)	Accuracy= 99.4 %	With a non-linear activation function and several layers, it is possible to learn non-linear transformations. Instead of learning one large transformation using PCA, it is more efficient to use an autoencoder.	Insufficient training data Training the wrong use case Too lossy Misunderstanding important variables Better alternatives.
	Alhassan et al. (2018)	Accuracy= 77.13 %		
	Leung et al. (2020)	TPR= 64 % AUC= 58 % G-Mean= 52%		
ICA	Wang et al. (2020)	Accuracy= 72.2 %	By changing the input space into a maximally independent basis, information may be separated. Simple to comprehend	Problem with overfitting Costly Loss of information Require more computation as compared to PCA

Figure 8 shows the accuracy comparison of various feature extraction methods. For PCA discussed by Abdulhammed, et al., 2019), the model has the highest accuracy almost 100 % as it Removes Correlated Features and also reduces overfitting while predicting. For AE (Alhassan, et al., 2019) the accuracy is also good compared with other methods.

Figure 9 shows the comparison of SMOTE, SVD, and AE considering G-Mean as a performance parameter. G-mean is an important parameter while dealing with class imbalance problems. The basic formula of G-mean is given below:

$$\text{G-Mean} = \sqrt{Specitivity * Recall}$$

As it has Specificity and recall the chances of considering the majority class is very low. Therefore, giving better performance. The SVD discussed by Chen et al., (2008) has the highest G-Mean nearly about 97.33%. For SMOTE discussed by Satriaji, et al. (2018), G-mean is 91.68 % and for AE it is minimum i.e., 52%.

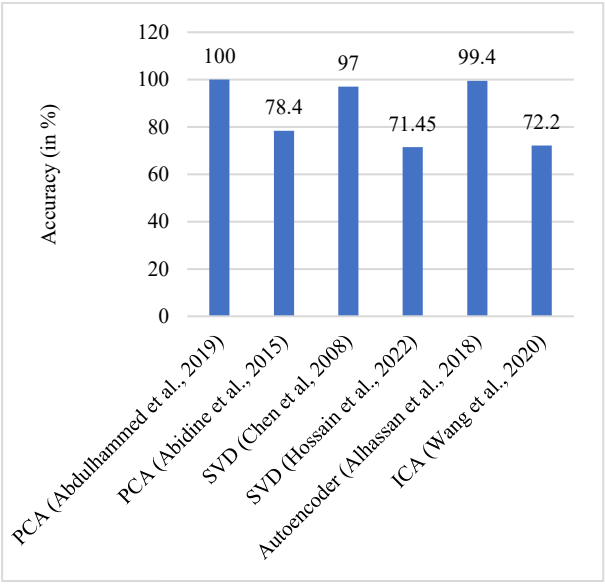

Fig.8. Accuracy Comparison of Feature Extraction based Techniques

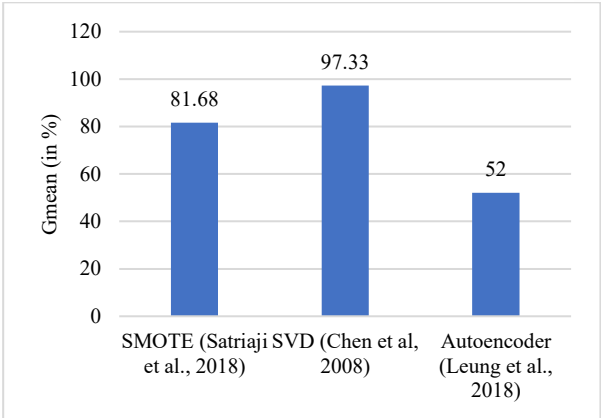

Fig- 9 G-mean Parameter comparison between different methods

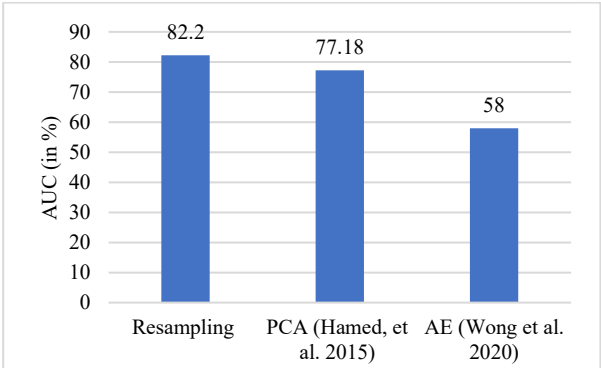

Fig- 10 AUC Parameter comparison between different methods

Figure 10 shows the comparison of Resampling, PCA, and AE using AUC as a performance parameter. It is clear from the graph that AUC is the maximum for a resampling method which is a very basic method to solve the data imbalance problem. The AE discussed by Wong, et al. (2020) has a minimum AUC of nearly about 58%.

Figure 11 shows the comparison of Resampling, PCA, and SVD using the F-1 score as a performance parameter. It is clear from the graph that for resampling

it is maximum. For PCA (Hamed, et al. 2015) it is 74.4 % and for SVD it is 70.78 %.

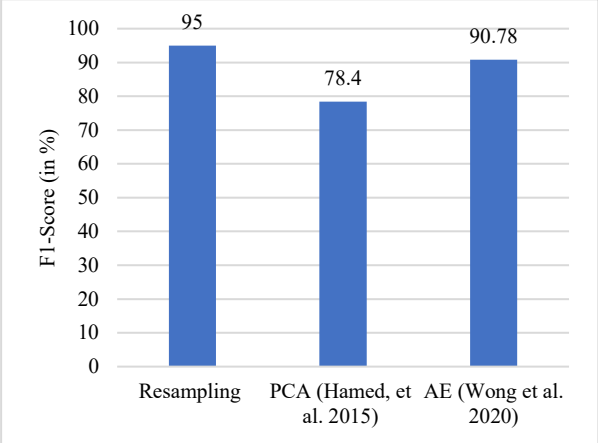

Fig- 11 F-1 Score Parameter comparison between different methods

5 Challenges and future research directions

The article suggests that there is a need for more sophisticated feature extraction approaches to address the class imbalance in time-series data. The focus would be on developing new techniques or adapting existing ones to handle imbalanced data. Ensemble methods and deep learning techniques are potential research directions that could improve classification performance on imbalanced time-series datasets. By improving feature extraction, researchers can improve the accuracy and reliability of classification models for imbalanced time-series data, which would be useful in areas such as fraud detection and disease diagnosis.

6 Conclusion

The task of detecting rare events is important in many domains, such as healthcare, signal processing, and finance. However, identifying these events can be challenging due to their infrequency and casual nature. Misclassifying rare events can lead to significant financial losses or even health risks. The detection process is also hindered by the problem of imbalanced data classification, where rare events are of greater interest but occur less frequently, making it difficult for classification algorithms to learn from them.

To address this challenge, the paper examines various feature extraction strategies for imbalanced time-series data. The goal is to develop effective approaches for feature extraction that can improve the accuracy and reliability of classification models for imbalanced data.

The paper compares the performance of different methods, including resampling, PCA, SVD, and autoencoder. Based on the given results, it can be concluded that the resampling method performs better than the other two feature extraction methods (PCA and AE) in terms of AUC and F-1 score for imbalanced time-series data classification. Resampling is a simple and effective technique to address imbalanced data, but it may result in overfitting or underfitting, depending on the type of resampling method used. PCA and SVD can help reduce the dimensionality of the data and extract relevant features, but they may not be effective in capturing complex relationships or patterns in the data.

Future research can focus on improving security management via time–series imbalanced learning. Because of the rapid rise of social media, internet security has gotten a lot of attention in recent years.

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Enhanced Roll Porous Scaffold 3D bioprinting technology

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Abstract

The upgrade of the Roll Porous Scaffold (RPS) 3D bioproduction technique provides significant advantages over today's dominant analogues. The density 10–15 μm cells in the formed object increased up to ~1.26×10^8 *cells/mL*. The improvement of droplet inkjet methods is achieved by draining excess water through a comb. In addition, a modified foam/lattice-based structure of the scaffold <1% *w/v* with a new support ribbon ensures cleaner and more precise biological object shaping. The updated RPS offers not only new hope for overcoming the shortage of organs for transplantation but also rejuvenation of the whole organism due to the forming of your own endocrine glands. It should be noted that albeit RPS is a project and has never used, it is a derivative of the time-tested methods and components of bioprinting. Potential of RPS for building multicellular tissue of high density and accuracy with a vascular system, with a width of 333 *mm* and a volume >1.7 *L* per hour at a layer thickness of 18 μm.

Keywords: 3D bioprinting, Bioadditive manufacturing, Tissue engineering, Biodegradable polymer, Roll Porous Scaffold

1. Introduction

Progress in 3D biofabrication, tissue engineering, and regenerative medicine holds great promise for anyone who wants to always be healthy, young, or rejuvenated.

Population aging and increased life expectancy have widened the gap between the shortage of tissue and organ transplants for transplantations "Karvinen et al. (2023)". The key to rejuvenation is not in nutrition, because if an old person and a child eat the same food, then the first one will continue to age, and the second one will grow. For this reason, it is logical to assume that hormones affect youth, and if their level is restored, then the whole body will look younger. The probability of rejection of bioprinted endocrine glands made from the man's DNA is minimal. These organs are much more complex than skin and cartilage and need vascularization to transport nutrients, oxygen, and waste "Leberfinger et al. (2019), Zhang et al. (2017)".

Achieving these goals with the help of modern bioprinters is difficult due to complex, heterogeneous biostructures with micro- and macrovascularization, innervation, differing in structural function, composition "Salg et al. (2022)" and mechanical properties.

Large arteries and their smaller branches (arterioles) have a layered wall structure, along which blood is transported to the capillary bed. Submillimeter sized capillaries consist of a single endothelial layer that provides permeability (gas exchange and nutrients). Macrovessels can be made-up in vitro, although with limited mechanical integrity "Freeman et al. (2019), Niklason et al. (2020)", while microvessels remain a challenge. Bioprinting of small capillaries is difficult since leading techniques allow the creation of vessels only >100 μm in diameter "Leberfinger et al. (2019)".

Appropriate mechanical properties and porosity are required to maintain the structure and growth of cells with a vasculature.

These specifications will depend on the rate and strength of the bioink crosslink, viscosity, and yield strength. Suitable plasticity of the bioink is necessary for printing, but at the same time, the shape must be maintained after printing to obtain sufficient dimensional integrity and mechanical strength.

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The RPS proposes to resolve listed difficulties fast and exactly at a low cost.

2. Methods and materials

2.1 Spiral coordinate system

Any 3D object can be transformed into a 2D stripe by the spiral coordinate system "Shulunov (2017a)" like a plane is transformed into a roll. This coordinate system defines a point's location in the volume with two and only one coordinate "Shulunov (2018)" instead of three in distinction from Cartesian one. The position of a voxel is determined by the length of the helix with tolerance depending on the constant h (the distance between successive turns). In RPS *h* is the height of the support ribbon, Fig. 1. Algorithms with their analysis "Shulunov (2017b), (2016a)" and software "Shulunov (2015), (2016b), (2016c), (2020)" for this coordinate conversion are described in detail in "Shulunov and Esheeva (2017c), (2017d)".

To make things clear Fig. 2 and Fig. 3 demonstrate the transformation of a tape filled with one and various components in order to form a multilayer tubular object from them in a wound roll.

Fig. 4 shows that schematic sequence of forming tubular branching object consists of different cell types.

2.2 Multicomponent support ribbon

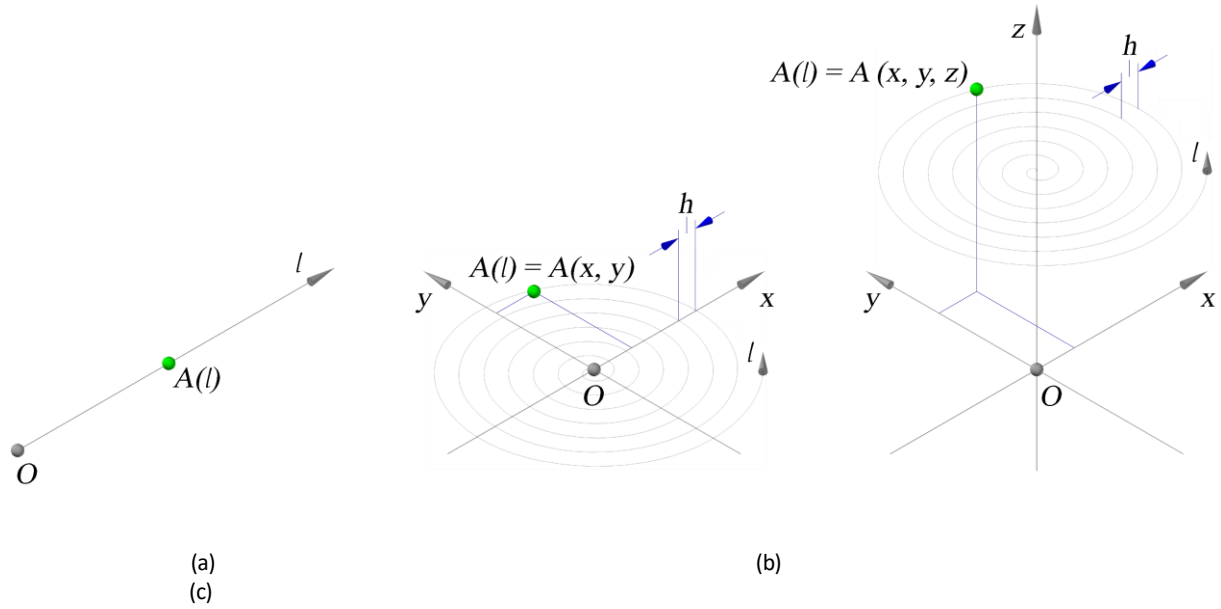
One of the most important components of RPS technology consists of supporting fine sieve, porous, attachable, and auxiliary tapes (Fig. 5).

The basis of the supporting element is perforated 5 μm aluminum foil with holes of 7×7 μm in size and a transparency of 49%.

The biodegradable polymer scaffold consists of combs 42×42×15 μm in volume with an area of 37×37 μm for placing 4 cells ∅10–15 μm because of 5 μm borders.

On the sides of the RPS ribbon are strips of incompressible material 18 μm high to ensure a constant layer thickness.

A 3 μm height attachable soluble tape with 49% transparency (7×7 μm holes with 3 μm selvedges) is used to stably delineate cell-filled helical layers.



(a) (b) (c)

Fig. 1. Definition of "A" point's location in 1D (a), 2D (b) and 3D (c) spaces.

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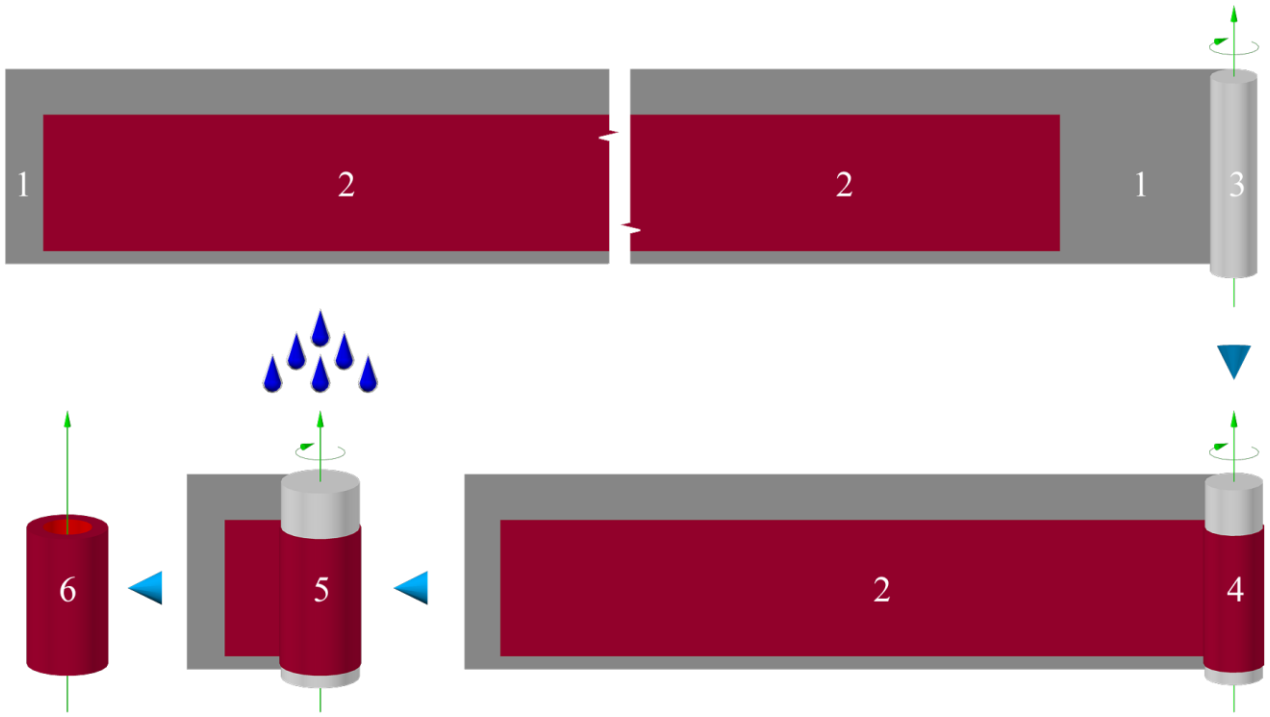

Fig. 2. Schematic sequence of transformation of a filled with cells water-soluble strip into a pipe object after its dissolution. (1) Empty scaffold ribbon, (2) Filled scaffold ribbon, (3) Roll forming object, (4) Tubular object inside the roll, (5) Almost formed object and support ribbon dissolving, (6) Object without scaffold.

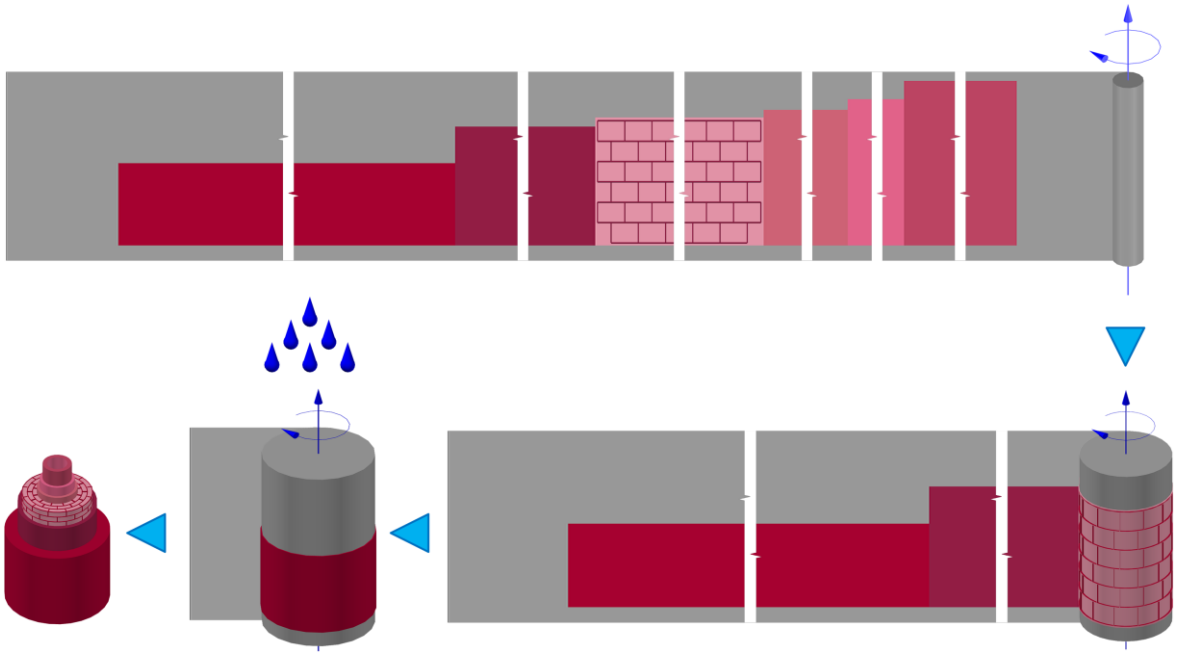

Fig. 3. Schematic sequence of formation of Tubular multilayer object of different cell types.

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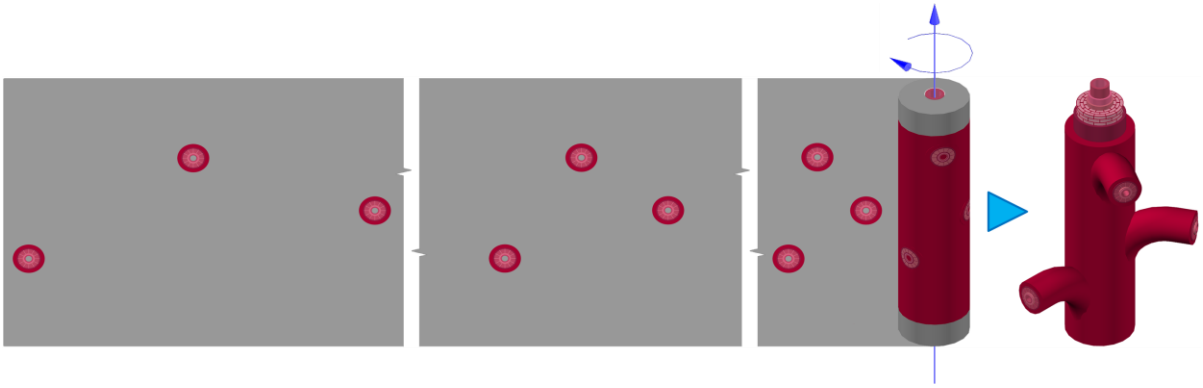
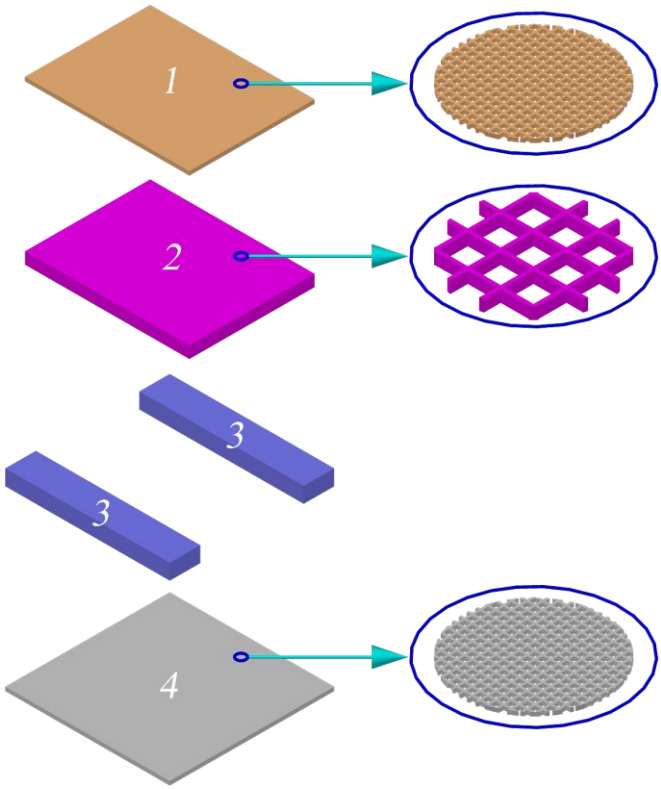
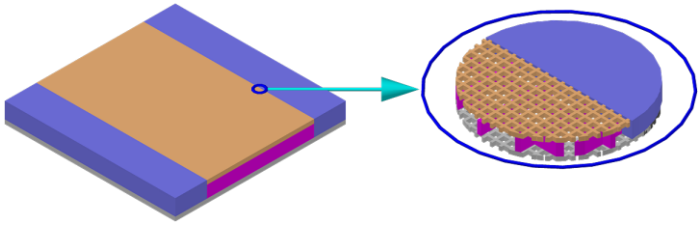


Fig. 4. Formation of a tubular branching object inside a roll.



(a)



(b)

Fig. 5. Simplified scheme of RPS multilayer support ribbon. (a) Layers in order connection, (1) Attachable soluble tape (7×7 μm holes with 3 μm selvedges) for precise delineation of filled layers, (2) Biodegradable polymer scaffold for cells with combs 42×42×15 μm, (3) Incompressible material with a height of 18 μm for constant layer thickness, (4) 5 μm aluminum foil with holes of 7×7 μm (transparency of 49%) for drainage. (b) All layers together.

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2.3 Wide, high-speed inkjet printhead

The standard Kyocera Inkjet Printhead "KJ4B-1200" shoots 339 968 000 drops of 5 *pL* per second by 5 312 nozzles at 64 *kHz* on a width of 112.42 *mm* at a paper pulling speed of 80 *m/min* (~1.33 *m/s*) and a resolution of 1 200 *dpi* (21×21 μm dot). Because each cell in the bioink is surrounded by a liquid volume of 1 000 *pL* (to guarantee fluidity) and ~200 drops are necessary to eject it out, by decreasing the speed of the tape to ~6.7 *mm/s* and removing excess water it is possible to reach cell quantity ~23 $(100/21)^2$, ~23×10^4 and ~1.13×10^8 on 100×100 μm^2, 1 cm^2 and in 1 cm^3 respectively for 20 μm layers. Using a 3 μm separation tape will lead to a layer thickness of 18 μm and increase the cell density up to ~1.26×10^8.

Therefore, the calculated performance for one usual serial piezo inkjet printhead is ~49 *mL/hour* (112.42×6.7×0.018×3 600).

The use of a line of 12 such heads makes it possible to form a biological object with a volume of ~0.58 *L* in an hour (cylinder ~112 *mm* high and ~81 *mm* in diameter).

Two parallel lines of these heads with an overlap of ~2.1 *mm* (100 nozzles) will provide a print width of ~223 *mm* and a throughput of ~1.15 *L/hour*.

2.4 ×100 increase of cell density in a porous matrix

The speed of inkjet Droplet Based Bioprinting (DBB) is higher than Extrusion Based Bioprinting (EBB) using pneumatic, piston, and screw driven printing, but the cell compactness is ~100 times lower. At first glance, DBB cannot outperform the cell concentration of EBB due to the bioink's high fluidity requirement. For sufficient fluidity without clogging the nozzles with bioinks, each cell ∅10–15 μm (~0.5−1.8 *pL*) requires ~600–1 900 times larger volume of ambient liquid (Fig. 6).

However, computations show the chance of raising this feature of DBB by orders of magnitude when using RPS 3D bioprinter with a multicomponent ribbon. Fig. 7 depicts its simplified scheme.

To increase the density of conventional ink bioprinting by ~100 times and achieve a cell density of ~1.26×10^8 cells per 1 *mL* for an 18 μm layer, it is suggested to pass this flow through a fine sieve.

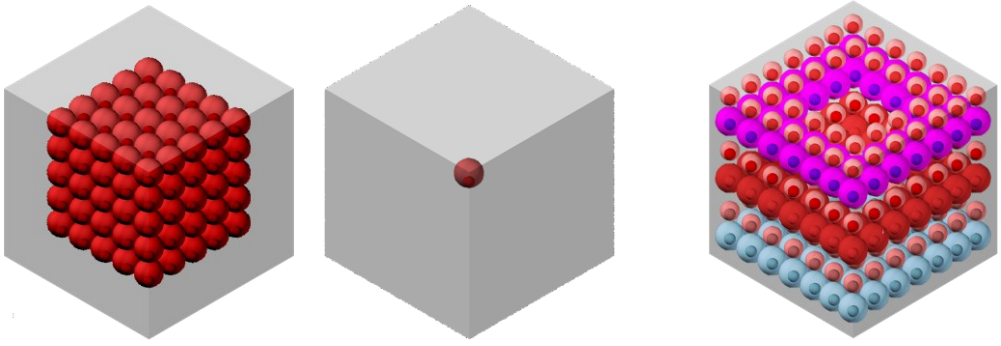
Separation of cells from the 1 000 *pL* flow occurs using a 37×37 μm (1 369 μm^2) comb with 49% transparency surrounded by 5 μm edging (the total square of the 7×7 μm holes with 3 μm borders will be ~671 μm^2). A drop with volume of ~5 *pL* (radius ~10.6 μm, cross-sectional ~353 μm^2) can easily pass through this area.

If a cell with a ∅10–15 μm is pressed against the perforated bottom by the low pressure of the assisting fluid drainage system and a sequence of droplets, then on average it occupies ~123 μm^2 on the comb.

When 4 cells take ~491 μm^2 then ~878 μm^2 (1 369 - 491) will remain for the passage of excess water droplets through the perforated bottom of the comb with a total area of holes ~430 μm^2 (878×0.49).

2.5 Stabilization of the cells position in the roll of the bioprinted object

High fidelity of cell positioning, resolution, structure, and shape stability must be ensured during and after bioprinting within the required time for the cell culture period "Li et al. (2020), Kyle et al. (2017)".



(a) (b) (c)

Fig. 6. Filling cells in a cube with a volume of 1 *nL*. (a) Adipose stem cells spheroid with minimum layer thickness of ~80 μm "Zhang et al. (2015)", (b) Approximate cell density limit in bioink for 3D inkjet bioprinting, (c) Possibility of printing with cells

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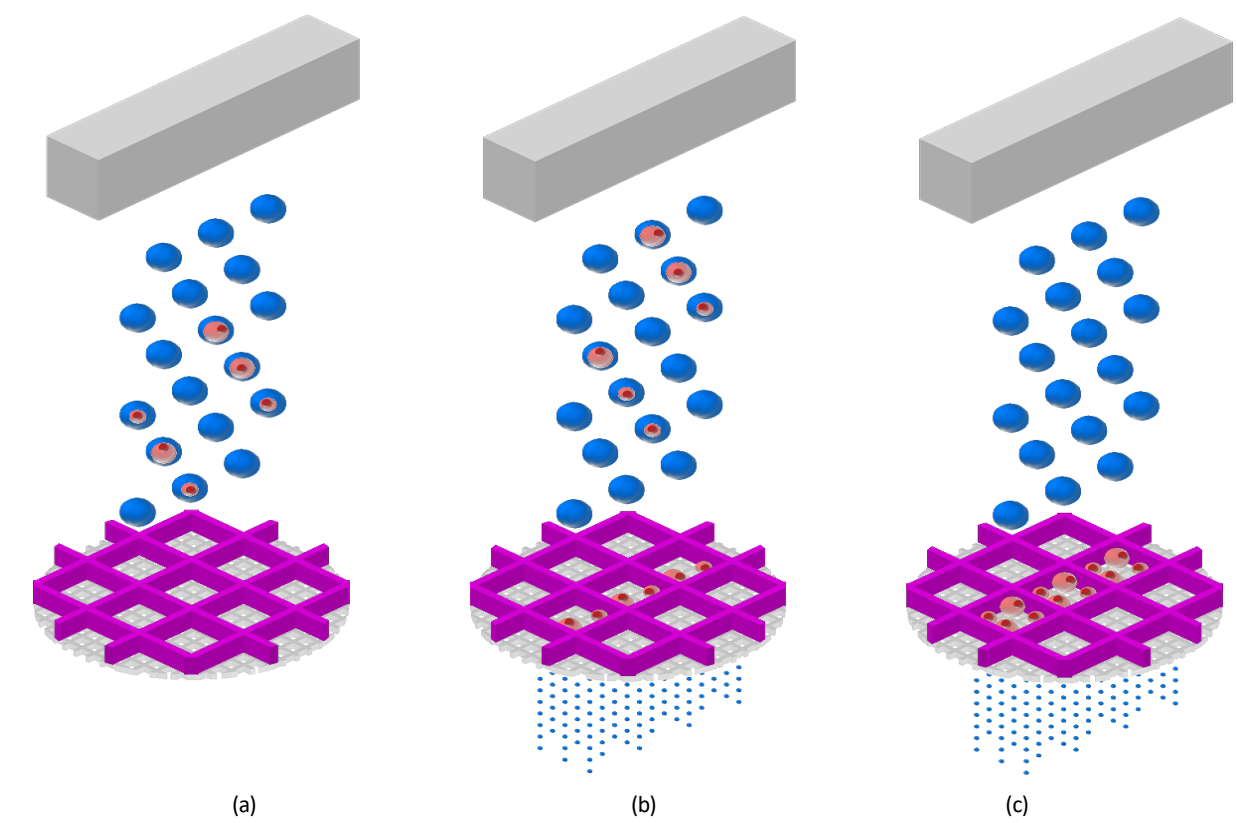

Fig. 7. Illustration of increasing the density of cell in the combs of the support ribbon by ~100 times up to ~1.26×10^8 *cells/mL* using a fine sieve for DBB. (a) Combs before filling with cells. (b) Combs with partial filling and drainage. (c) Combs completely filled with cells during removal of excess water.

In RPS, a porous comb scaffold 15 μm high and 5 μm wide is used to limit cell displacement in the layer. Non-mixing of layers with each other is created by a supplementary porous soluble foam/lattice-based ribbon with a thickness of 3 μm after placing the cells in the layer. The total admixture of the scaffold in the shaped biological object is <1%.

The ranges of distances between cells in 1 and neighboring layers are presented in Fig. 8. The distances between cells determine their interactions and tissue growth. For a pair of the smallest 10 μm cells, the maximum distance is 8−17 μm, and for 15 μm one 3−7 μm in the adjacent layer and within its comb accordingly. The biggest 4 cells (∅7.5 μm) will occupy ~7 pL of a 32 pL (42×42×18 μm) comb voxel and there is enough space for them to swell and proliferate, after the bioink is placed into a porous scaffold, and allow therapeutics or waste products diffusion.

2.6 Basic RPS algorithm for 3D bioprinting

First, the tape is precisely rewound from roll (1) to roll (2) using rollers (3, 4) and a tension control system (5), Fig. 9. Then the drip filling system (6) fills it with various bioinks in accordance with the required tissue from a plurality of reservoirs installed above it. Excess ink water is removed by a drainage system (7) with a vacuum pumping system (13) into a tank (14). When the frame has been formed and filled with nutrient fluid from tank (12), it is covered with tape (9) separating the layers. The supporting foil is wound on a roll (10). The accuracy of the ribbon (reinforced and side-perforated like cinema film) winding is controlled by the frame's position and merging control

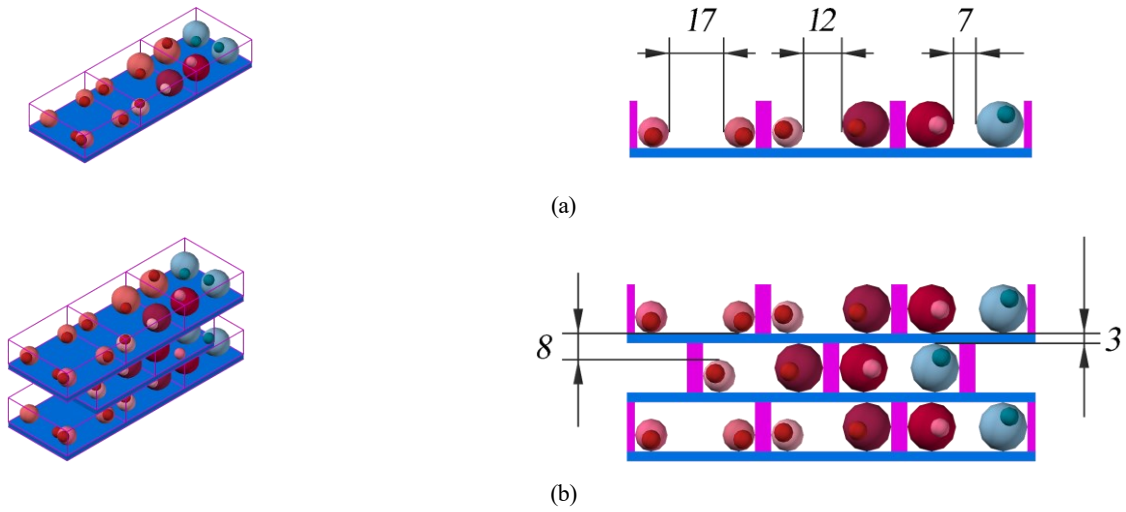

Fig. 8. Cells in a porous comb scaffold (isometric and side views), (a) the range of distance between cells 7−17 μm in 1 layer, (b) the range of distance between cells 3−8 μm in 3 layers.

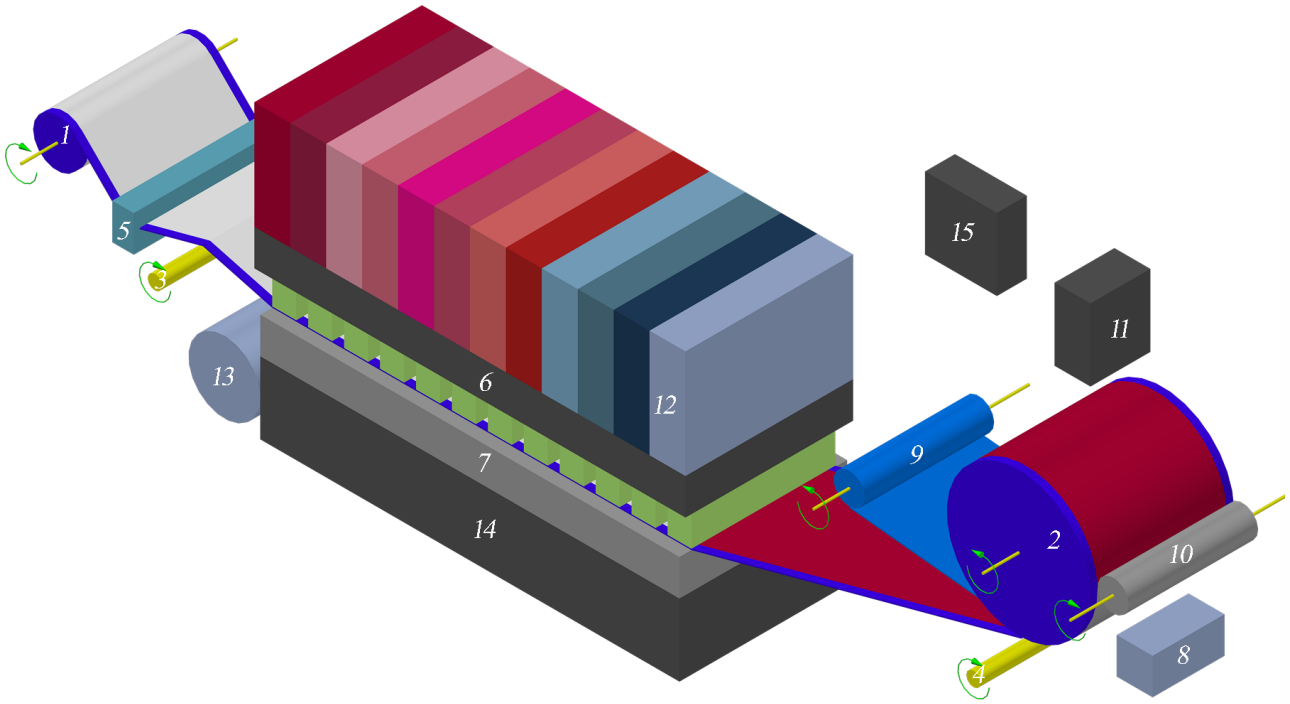

Fig. 9. Simplified general view of the enhanced RPS 3D bioprinter. (1) Scaffold roll, (2) Bio-object roll, (3) and (4) Extending rollers, (5) Supply roll unreeling tension control system, (6) Array with linear inkjet printheads with multiple reservoirs for each type of bioink, (7) Low pressure drainage system to remove auxiliary fluid, (8) Bio-object roll layer merging control system, (9) Attachable soluble tape for precise delineation of filled layers, (10) Aluminum foil with holes for drainage, (11) Frame position on the scaffold roll control system, (12) Nutrient fluid tank, (13) Vacuum pumping system, (14) Tank for excess water from bioink, (15) Component synchronization system.

systems (8) and (11). All these components are synchronized by system (15). Since the computed 3D CAD model of the bioprinting object is divided into frames, the position of all of them on the scaffold ribbon is known in advance by the length. The system verifies the actual and planned location for each frame. To correct possible distortion, the next one is shifted (by software) forward or backward according to the location of the marks, more details about "Frame position on the scaffold roll control system" are in the "Shulunov (2019)".

5. Results and discussion

Despite great advances in 3D bioprinting technologies for tissue engineering (without the lack of only planar cell-cell interactions), regenerative medicine, "organ on a chip" systems, and drug evaluation, there are still some challenges to be solved.

The currently dominant bioprinting methods compared in Table 1 do not allow solving a number of problems with exactly directed tissue mimic and providing transportation of nutrient and metabolic waste, blood supply and long-term survival of the cellular structure.

For example, it is difficult for EBB to print hollow tubes with an appreciable length-to-width ratio without using complex consumables in multiple printing processes.

EBB uses fugitive inks and endothelialization to print vascular networks. This sacrificial indirect bioprinting used to form hollow vessels consists of four steps: (1) solid sacrificial microfiber bioink is applied, (2) stromal cell-embedded hydrogel is applied to templated microfibers, (3) perfused channels are formed by selective fiber removal (e.g. temperature-induced phase transition, dissolution or mechanical extraction, etc.) under conditions suitable for the cells, and (4) functional vessels are built by seeding endothelial cells into the interior of the microchannels. This method is considered indirect bioprinting.

Alternatively, "Zhang et al. (2017), (2018)", channels are printed using direct bioprinting "Leberfinger et al. (2019)". These strategies for fabricating vascularization can be further divided into four groups "Salg et al. (2022)": 1) sacrificial bioprinting "Song (2018)", 2) sacrificial writing in functional tissue, SWIFT "Skylar-Scott et al. (2019)", 3) immersed bioprinting (reversible embedding of free-form suspended hydrogels, FRESH "Lee et al. (2019)") and 4) coaxial bioprinting "Gao et al. (2018)".

Innervation contributes to the development of tissues and organs, but also plays a central role as a tool for their functional control and modulation "Das et al. (2020)". Nerves provide the work of the auditory, skeletal or smooth muscles containing tissues (e.g. the stomach or bladder) "Das et al. (2020), Jammalamadaka and Tappa (2018)" and must have their own channels.

Complex three-dimensional organs require precise multicellular systems with vascular integration, which is currently not possible with traditional bioprinting methods.

The RPS has been designed to overcome all the problems mentioned above at a lower cost than the present dominant technologies.

The specifications of the new technology were developed or the simultaneous bioprinting multicellular tissue equipped with blood vessels with high exactness and density ~1.26×10^8 *cell/mL* by matrix of fixed printheads for each type of cells (bioink of endothelial,

Table 1. Comparison of printing methods for bioprinting.

Bioprinting techniques	**Extrusion**	**Laser**	**Inkjet**	**Enhanced RPS**
Cell diameter, *μm*	80–300 (cell spheroid)	20–80	10–50 (1–100 *pL*)	
Resolution	Medium	High		
Printing speed	Slow	Medium	Fast	
Cell density, *cells/mL*	~10^8		<5×10^6	~1.26×10^8
Cell viability, %	97	>97	85–98	
Cost	Medium	High	Low	

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Table 2. RPS 3D bioprinting based on inkjet technology.

Title	Previous RPS	Enhanced RPS
Cell density, *cells/mL*	$<5\times10^6$	$\sim1.26\times10^8$
Layer thickness, *μm*	20	18–20
Print width, *mm*	112–333	
Performance, *L/hour*	>1.7	
Print volume, *L*	~5	
Transfer belt	Yes	No
Safety reeling protector		
Transfer belt tension control system		
Transfer belt refinement system		
Low pressure drainage system to remove auxiliary fluid	No	Yes
Attachable soluble tape for precise delineation of filled layers		
Aluminum foil with holes for drainage		
Nutrient fluid tank		

smooth muscle, fibroblast, cartilage, collagen, osteoblasts, nerve and stem cells, etc.).

An array of three lines of 12×112.42 *mm* printheads with ~4.2 *mm* (2×100 nozzles) overlap will produce 333 *mm* wide bioobject with a performance of >1.7 *L/hour*.

At the same or better resolution than the previous version of bioprinting, enhanced RPS techniques have higher cell density and a simpler design (Table 2).

Form stability after printing is ensured by an easily dissolved porous ribbon scaffold (post-processing stabilization is not required) that withstands dynamic mechanical stress and promotes rapid vascularization with cell growth and proliferation.

Comb-shaped, side-reinforced tape, composed of soluble *nano*fibers and spongy biomaterials, creates a spatially mediated microenvironment and controlled intercellular distance with a high density of selected cells.

These scaffolds made of micron comb tape with 49% transparency ensure that droplets of cells do not move in their layer and do not mix with the neighboring one and do not flow out of the calculated places.

4. Conclusion

Enhanced RPS for the creation of biological objects is based on the use of linear matrices of multiple inkjet heads and a multicomponent support ribbon, which can be used to improve the biomodel of an organ tissue on a chip for testing new drugs on it.

A new RPS 3D bioprinter has been developed that outperforms dominant technologies. Its specifications are derived from commercially available inexpensive usual piezoelectric inkjet printer components suitable for bioinks as they do not heat cells. Expected properties for the manufacture of a biological object with a matrix of three lines of 12 printheads are: layer thickness of 18 *μm*, voxel comb resolution 42×42×18 *μm* for 4 cells with a size of ~10–15 *μm*, density of $\sim1.26\times10^8$ *cells/mL*, width 333 *mm* and throughput up to >1.7 *L/hour*.

The main workflow is simplified, requires fewer components, and improves purity of formed objects. The admixture of foam/lattice-based structure water soluble scaffold in the formed biological object is <1%.

The new technology proposes to create in vitro complicated organs like endocrine glands with precise multicellular systems equipped with vascular network

integration, which cannot be done by traditional leading bioprinting technologies.

The paper shows ways to overcome the main technological barriers of 3D bioprinting for organs and significantly accelerate the bioproduction of large complicated multilevel cellular structures, tissue engineering, organ patch, or organ transplants for transplantations, regenerative and rejuvenation medicine in the near future.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Deep blockchain-enabled security enhancement in trade finance

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Abstract

Trade networks powered by blockchain can benefit all parties involved by lowering. The friction produced by operational and logistical inefficiencies in the trade finance value chain. By reducing duplications and ineffective execution, blockchain would be crucial in the short run for streamlining company processes. However, the lack of confidence in the security of trade financial data due to financial issues brought on by a bandwidth difference and the use of unsafe data in trading finance has become a challenging issue. Hence a novel Blockchain crypto trading innovation has been presented in which the smart contract is used to enhance the financial trade and the deep mongrel-manner spectral hashing synchronization algorithm provides the special hashing function thus the hashing can be only generated by the consumer of the trader it is the safest way for the trade financing thereby it improves the trade finance process, transaction bandwidth, improve the security of the trade finance and decrease the alter of block data. The results showed that the proposed approach successfully addressed the security concerns, and compared the proposed approach with other popular methods, such as the Data Encryption Standard (DES), 3 DES, and Advanced Encryption Standard (AES). The proposed method is compared to several cryptographic techniques' performance metrics, including throughput, times consumption of encryption and decryption process, and key generation. The result obtained showed that the proposed technique has a high performance in throughput, decryption, encryption rate and key generation time is lower than other existing algorithms.

Keywords: Blockchain, trade finance, smart contract, deep network, synchronization, transaction bandwidth.

1. Introduction

Trade is defined as the voluntary exchange of goods or services between different economic groupings. The parties are under no duty to one other to trade, thus a transaction will only happen if both parties think it will improve their interests. In certain circumstances, the trade might have more precise connotations. Trade in the financial markets refers to the buying and selling of derivatives, commodities, and securities. Free commerce refers to cross-border exchanges of goods and services that are unhindered by tariffs or other trade restrictions [Lupo-Pasini, F. (2019)], [Haberly, D. and Wójcik, D. (2022)]. Trade refers to the voluntary exchange of commodities or services between economic actors. Because contacts are voluntary, commerce is usually assumed to benefit both parties. Trading in finance is the purchasing and selling of securities or other assets. According to the comparative advantage concept, trade benefits all parties involved. Although some development economists believe protectionism has benefits, the majority of traditional economists advocate free trade [Dobler, G. and Kesselring, R. (2019)], [Block, J.H., et al. (2021)], [Meyers, D., et al. (2020)]. Financial innovation refers to the process of creating new financial products, services, or methods. Financial innovation has been aided by advancements in financial instruments, technology, and payment methods. Because of digital technology, the financial services sector has undergone a transition, which has

also changed how people save, borrow, invest, and make purchases. [Machkour, B and Abriane, A. (2020)], [Palmié, M., et al. (2020)].

Blockchain provides real-time data on transactions between many parties, such as corporations, distribution networks, investment pools, and a global supply chain, allowing data to be securely stored digitally. It gives everyone access to a record that is safe, encrypted, clear, accessible, and hard to tamper with. Even though blockchain entered the financial system with the introduction of the cryptocurrency Bitcoin, it is now utilized in a variety of activities, including those connected to international commerce, either directly or indirectly[Laroiya, C., et al. (2020)], [Abbas, K., et al. (2020)]. Adoption of this technology could help shorten the drawn-out value chain of international trade, which involves some intricate sectors like logistics, transportation, customs administration, financing, and administrative procedures between enterprises [Ren, L., et al. (2021)]. A blockchain is a distributed database or ledger that is shared across computer network nodes. A blockchain is an electronic database used to store data in digital form. The most well-known application of blockchain technology is in cryptocurrency systems such as Bitcoin to keep a secure and decentralized record of transactions. [Farahani, B., et al. (2021)], [Ghaffari, F., et al. (2020, September)]. In a blockchain, data is organized into groupings called blocks, which each include collections of data. When a block's storage capacity is reached, it is sealed and joined to the block that came before it to form the data chain known as the blockchain. Every new piece of information that follows that freshly added block is merged into a new block, which is then added to the chain once it is complete. [Carvalho, A., et al. (2021)], [Benisi, N.Z., et al. (2020)]. A blockchain is a type of shared database that differs from other databases in that it saves data in blocks that are then linked using encryption. [Xu, X., et al. (2019)]. With each new piece of data that enters, a new block is formed. Once a block has been filled with information and connected to the block before it, the data is chained together in chronological order. Although different types of information may be stored on a blockchain, a transaction ledger has been its most common application thus far. [Huang, S., et al. (2020)]. The goal of blockchain is to make it feasible to communicate and record digital information without having to alter it. A blockchain is a foundation for immutable ledgers, which are records of transactions that cannot be modified, erased, or destroyed. Because of this, blockchains are also known as distributed ledger technologies (DLT) [Shrivastava, S and Sharma, A. (2022)], [Al-Rawy, M and Elci, A. (2021)], [Li, J and Kassem, M. (2021)].

By using a blockchain to securely store the contracts and employing smart contracts to automate the execution of sales contracts, blockchain can be used to improve importer-exporter relationships. With output-based smart contracts that are executed when all predefined conditions are met, this is possible [Kersic, V., et al. (2019, June)]. Conditions are satisfied and are two significant parties who gain from using blockchain for business transactions both an importer and an exporter desire assurance that the contract conditions are accurately executed. The fast-moving technological progress of today has made it possible for the phenomenon of financial innovation (FI) to spread solutions meant to address market gaps, leading to significant changes in the conventional financial structure [Andoni, M., et al. (2019)], [Bali, S. (2020)], [Dinnetz, M.K and Mireles, M.S. (2022)]. The existing works on blockchain-enabled security enhancement are carried out only in finance but they do not involve trade finance in the security enhancement thus due to the importance of trade finance it is a required area of research. It has become necessary to due to the development of technology-based threats such as cyber-attacks and malicious hacking, alternative methods for building more safe and sustainable corporate financing must be found through developing new and innovative working paradigms., which have endangered business operations and financial practices in the existing trading using the blockchain. Due to having an enhancement in the security of trading finance, the novel blockchain-enabled model is needed in trade finance. With the blockchain acting as a shared ledger (database), which keeps transparent records of crucial transactions between trading players, trade financing may be made easier. The blockchain may improve supply chain traceability and transaction transparency [Saberi, S., et al. (2019)]. The following are the primary contributions of this paper,

- In trade finance, the deep blockchain-enabled security enhancement provides the smart contract which is used for the security of the trade finance thus the smart contract in the trade will provide a certified safety measure in the trading finance without bandwidth difference.
- A novel Blockchain-enabled crypto trading innovation has been introduced that utilizes

specialized tokens, and smart contracts within blockchain technology to manage trade finance which provides security in the trade finance of industries or organizations by cryptography.

- During the deep mongrel manner, the spectral hashing algorithm process is carried out it provides better security with the hashing function and key generation thus the key generation at the receiver part is also secured with the hashing function.

The following is how the paper's material is organized: Section 2 relates to the literature review, Section 3 describes the approach and the innovative solution, Section 4 presents the results, and Section 5 concludes the study.

2. Literature Survey

Wang et al [Wang, L., et al. (2021)] proposed a model of the supply chain with one supplier and two Investigating how trade credit affects both vertical and horizontal supply at competing merchant interactions in chains. Because of the ambiguous market demands, retailers are involved in Cornet competition.: It may make the competition between two retailers worse or lessen it. It's interesting to note that when two stores whenever a store is in financial difficulties due to imbalanced financial positions, the supplier is. There is a bidirectional pattern of predation between the two shops. Furthermore, it demonstrates that a retailer always gains from being in better financial shape. However, depending on the level of competition and the uncertainty of the demand, an improvement in the competitor's financial situation might be advantageous or detrimental to the retailer. The degree of competition and the degree of demand unpredictability may also have an impact on the supplier's preference for the financial health of the retailers.

Henninger et al [Henninger, A. and Mashatan, A. (2021)] proposed the global supply chain is a network of interconnected processes that were not intended to communicate with one another but still produce, use, and exchange records. To realize the complete utilization of supply chain management (SCM) technologies, network and record system compatibility involved in the collaboration must be achieved. We provide an overview of the current state of distributed ledger technology practice (DLT)and examine the research and solutions that have already been done in this area. As a result, we also suggest a comprehensive approach: a DLT-based future state that might enable the interoperable, effective, reliable, and secure transmission of data with integrity. Moreover, it does a gap analysis for a variety of fractional DLT-based SCM systems and compares our expected future state to the existing state. However, in the absence of interoperability, information is fragmented and the technology cannot be used to its full potential.

Deng et al [Deng, S., et al. (2021)] proposed building a supply chain model with one supplier and two competing retailers. The supplier, a sizable manufacturer with sound financial standing, is able to grant trade credit to the two downstream stores, which might require it. With unclear market demands, the two retailers are engaged in Cournot's competition. Demand risks could put a financially troubled retailer at risk of bankruptcy, which could be vertically transmitted through trade credit to the upstream supplier. Horizontally, the other retailer's competitive strategy and profitability will be impacted by the trade credit of one shop and the following bankruptcy risk. We discover that trade credit has two opposing effects on downstream retailers' purchasing decisions: it may either intensify or moderate competition between two merchants. It's interesting to note that when two retailers' financial situations are out of balance, the supplier may rescue the financially troubled retailer, and predation between the two shops shows a bidirectional pattern. Furthermore, we demonstrate that a retailer always gains from being in better financial shape. However, depending on the level of competition and the uncertainty of the demand, an improvement in the competitor's financial status could be beneficial or damaging to the shop.

Wang et al [Wang, R., et al. (2019)] proposed the concept of supply chain financing idea was clarified along with its purpose, and the theoretical underpinnings of supply chain financial risk management were investigated. On this foundation, operational risks were highlighted while risk sources and supply chain finance-impacting factors were examined. The Internet of Things (IoT) technology's unique function and the business model for inventory financing mode were combined to create a new financing mode for inventory pledges. It was discovered that the supply chain finance mode was based on comparing the anticipated loss (ES) value of the inventory pledge financing method based on IoT with the operation risk of the old mode, IoT technology drastically reduced the operation risk. The findings demonstrated a considerable difference in the value of risk loss owing to different types of loss events in the operation risk of supply chain finance inventory

pledge financing technique, with external fraud producing the most losses.

Dong et al [Dong, G., et al. (2021)] proposed a supply chain with two tiers that include a merchant and a manufacturer of low-carbon goods participants in the supply chain can successfully overcome financial restrictions by implementing a portfolio financing strategy that incorporates asset-based securitization, trade credit, and bank loans (ABS). We discovered that only when customers are particularly price sensitive to low-carbon commodities can tax preferences induce producers to reduce output under the BL and DC financial modes (Dual credit refers to the combination of bank loan and trade credit). The cash flow under portfolio financing is the narrowest as compared to pure BL and DC. Additionally, it considered the multi-stage scenario's capital demand. Additionally, when specific criteria are met, it was discovered that the tax rate and tax deduction ratio of carbon emissions reduction will have an influence on the retail price, wholesale pricing, and financing decision in the three financial modes.

Razavian et al [Razavian, E., et al. (2021)] proposed a long-term supply chain model, and effective in the face of interruptions, taking both material and financial considerations into account. Modeling disruption risks involves the use of probabilistic programming. Uncertain product demand is taken into account using two-stage stochastic programming. Conditional-Value-at-Risk that can perform well in the worst-case circumstances. Finally, the applicability of the provided model is proven and significant managerial insights are gained based on computer experiments conducted on a real-world case study as well as various test situations. it is stated that using various financing options to pay for raw materials will enhance supply chain performance and favorably boost supply chain profitability. Disruption risks, also known as high impact, low probability risks, can, however, significantly affect the functioning of the supply chain and are typically brought on by naturally occurring phenomena.

Ding et al [Ding, Y., et al. (2021)] proposed a two-tier supply chain made up of a third-party provider, numerous distribution centers (DCs), and numerous retailers. The upstream suppliers' trade credit is available to the retailers. An integrated DC-retailer network design model is therefore proposed to optimize trade credit terms and safety stock levels, as well as the selection of DC sites, DC-retailer assignments, and inventory replenishment criteria. The classic warehouse retailer network design model's critical mathematical structure is preserved in the trade credit financing cost description. This algorithm works well for problem instances with a practical size. The findings indicate that including trade credit finance in the architecture of the supply chain network may significantly lower the overall cost. For a thorough knowledge of how operational and financial factors affect supply chain optimization, the variance of each cost component is also examined. However, it seems that the diversity in funding profits has little impact on the number of DCs built. the complete cost breakdown

Lin et al [Lin, Q and Qiao, B. (2021)] proposed that to explore the link B&T's connection, as well as the consequences of economic volatility, incomes, prestige, and ownership, the panel data of all Numerous conclusions are drawn. First, there is a complementary relationship, which is influenced by changes in the economy, business success, social standing, and ownership. Second, B&T's relationship is negatively impacted by changes in the economy, profit, status, and ownership. The complementing advantages will fade as the perception of economic volatility, profit, prestige, and ownership fades. Lastly, economic fluctuations, status, profit, and ownership have a greater impact on the relationship between bank loans and accounts payable than on the relationship between bank loans and accounts receivable.

Li et al [Li, Y., et al. (2022)] proposed the implications of customer transfer in a dual-channel supply chain with capital limitations and looks optimum operational choice by considering a Stackelberg game. When dealing with stochastic demand, the trade credit coordination mechanism is found in the supply chain. The findings indicate that a trade credit contract would reduce the financial strain on a capital-constrained merchant and accomplish supply chain coordination across two channels. Additionally, using trade credit motivates retailers to submit orders. However, compared to a shop with enough capital, the retailer with capital constraints faces a higher default risk when using trade credit. In a dual-channel supply chain, the manufacturer and retailer share the risk through trade credit.

Yan et al [Yan, N and He, X. (2020)] investigate profit maximization with and without bankruptcy costs capital-constrained choice objectives and broadens to multi-attribute utility maximization (MAU), which incorporates attributes of predicted sales revenue, bankruptcy cost, and service level. Surprisingly, we

discover that in an imperfect capital market, depending on bankruptcy costs and the retailer's preferences for decision-making features, the optimal order quantity for the capital-constrained retailer with trade credit financing may surpass the well-funded order quantity. This demonstrates that trade credit may induce retailers to raise order size, thus improving the overall profitability of the supply chain. The ideal order size would be lower than that required to maximize expected profit. But still, this incentive effect diminishes when the bankruptcy cost is quite large or when the bankruptcy cost has received a lot of attention.

Nguyan et al [Nguyen, Q.K. (2016, November)] discovered successful tests of the credit default swap recordkeeping technology used in Bitcoin allowing banks fully comprehend the main financial movements. Blockchain also assists in separating the tasks of saving and sending money, making it easier for startups to send and receive funds as well as convert to US dollars. Additionally, blockchain assists managers in handling financial transactions directly. So that the banks can better understand significant financial changes regarding Bitcoin credit default swaps. Anyhow, the Banks are under pressure from shareholders to increase profits, and regulators want their business models to be quickly simplified.

Chang, S.E et al [Chang, S.E., et al. (2019)] proposed a potential paradigm shift in trade finance utilizing blockchain technology and it gives the overview of many applications using a multiple-case study approach and comparison analysis to gain insight into the parallels and discrepancies across blockchain-based L/C applications. Here it states some benefits such as cost reduction, the establishment of trust-free mechanisms, increased efficiency, enhanced transparency, and accountability by using blockchain. Even though, scalability, platform standard, legal effect, distributed governance, and social impact, have a crucial influence on the future adoption

Nakasumi, M.et al [Nakasumi, M. (2017, July)] combined a blockchain with a homomorphic encryption solution and presented a fresh blockchain information-sharing system. It has several advantages for supply chain management. Transaction data shouldn't generally be placed in the hands of other parties since they might be stolen and used inappropriately. Users should manage and own their data instead, without sacrificing security or impeding businesses' and governments' capacity to offer encrypted transactions. Users are constantly made aware of the information that is being gathered about them and how it is used, and they are not obliged to put their faith in any third party. It is difficult in case of search operations for emergency orders bringing a heavy load to Miner.

S. E. Chang et al [Chang, S. E., et al.] experimented with practical trade flow with a smart-contract-enabled event-driven scheme by utilizing a distributed ledger as an interaction and facilitating tool. It is one of the more secure payment methods which renders international trade to a more efficient level. The suggested system offers several trade partners a dispersed working environment. Such a system, which is maintained by a consortium network, might improve trade efficiency and process flow. However various TOE (Technology, Organisation, Environment) factors affect the implementation of blockchain applications.

Table 1: Comparison of research papers

Name of the Authors	Proposed technique	Advantages	Limitation
R.Wang et al [Wang, L., et al. (2021)]	Supply chain with one supplier and two Investigating	Retailer always gains from being in better financial shape.	The degree of competition and the degree of demand unpredictability have an impact on supplier performance
Henninger et al [Henninger, A and Mashatan, A. (2021)]	The global supply chain is a network of interconnected processes and does a gap analysis for a variety of fractional DLT-based SCM systems	The expected future state is better than the existing state of the SCM system.	Absence of interoperability, information is fragmented and the technology cannot be used to its full potential.

Deng et al [Deng, S., et al. (2021)]	Building a supply chain model with one supplier and two competing retailers	When two retailers' financial situations are out of balance, the supplier may rescue the financially troubled retailer, and predation between the two shops shows a bidirectional pattern	Demand risks could put a financially troubled retailer at risk of bankruptcy, which could be vertically transmitted through trade credit to the upstream supplier. Horizontally, the other retailer's competitive strategy and profitability will be impacted
L.Wang et al [Wang, R., et al. (2019)]	The concept of supply chain financing idea was clarified along with its purpose, and the theoretical underpinnings of supply chain financial risk management	IoT technology drastically reduced the operation risk. Real-time ride-sharing has so far been one of the most popular application scenarios	Operation risk of supply chain finance inventory pledge financing technique, with external fraud producing the most losses.
Dong et al [Dong, G., et al. (2021)]	A supply chain with two tiers that includes a merchant and a manufacturer of low-carbon	The supply chain can successfully overcome financial restrictions by implementing a portfolio financing strategy that incorporates asset-based securitization, trade credit, and bank loans (ABS).	The cash flow under portfolio financing is the narrowest as compared to pure BL and DC.
Razavian et al [Razavian, E., et al. (2021)]	A long-term supply chain model, and effective in the face of interruptions	Using various financing options to pay for raw materials will enhance supply chain performance and favorably boost supply chain profitability	Disruption risks, also known as high impact, low probability risks, can, however, significantly affect the functioning of the supply chain
Ding et al [Ding, Y., et al. (2021)]	A two-tier supply chain is made up of a third-party provider, numerous distribution centers (DCs), and numerous retailers.	It includes trade credit finance in the architecture of the supply chain network may significantly lower the overall cost.	Diversity in funding profits has little impact on the number of DCs built. And complete cost breakdown
Lin et al [Lin, Q and Qiao, B. (2021)]	To explore the link B&T's connection, as well as the consequences of economic volatility, incomes, prestige, and ownership, the panel data of all Numerous conclusions	It will fade as the perception of economic volatility, profit, prestige, and ownership fades	Economic fluctuations, status, profit, and ownership have a greater impact on the relationship between bank loans and accounts payable than on the relationship between bank loans and accounts receivable
Li et al [Li, Y., et al. (2022)]	Implications of customer transfer in a dual-channel supply chain with capital limitations	A trade credit contract would reduce the financial strain on a capital-constrained merchant and accomplish supply chain coordination across two channels.	Compared to a shop with enough capital, the retailer with capital constraints faces a higher default risk when using trade credit

Yan et al [Yan, N and He, X. (2020)]	Investigate profit maximization with and without bankruptcy costs	Credit may induce retailers to raise order size, thus improving the overall profitability of the supply chain.	This incentive effect diminishes when the bankruptcy cost is quite large or when the bankruptcy cost has received a lot of attention.
Nguyan et al [Nguyen, Q.K. (2016, November)]	Discovered successful testing of blockchain technology in financial operations	Banks can better understand significant financial changes regarding Bitcoin credit default swaps	Banks are under pressure from shareholders to increase profits, and regulators want their business models to be quickly simplified.
Chang, S.E et al [Chang, S.E., et al. (2019)]	A potential paradigm shift in trade finance utilizing blockchain technology	Cost reduction, the establishment of trust-free mechanisms, increased efficiency, enhanced transparency, and accountability	Scalability, platform standard, legal effect, distributed governance, and social impact, have a crucial influence on the future adoption
Nakasumi, M.et al [Nakasumi, M. (2017, July)]	Combining a blockchain with a homomorphic encryption solution	Users are constantly made aware of the information that is being gathered about them and how it is used, and they are not obliged to put their faith in any third party.	Search operation for emergency orders brings a heavy load to Miner.
S. E. Chang et al[Chang, S. E., et al.]	The smart-contract-enabled event-driven scheme is incorporated into practical trade flows by utilizing a distributed ledger as an interaction and facilitating tool.	It is one of the more secure payment methods which renders international trade at a more efficient level	Various technical, organizational, and environmental factors affect the implementation of blockchain application

From the analysis it is noted that [Wang, L., et al. (2021)] The degree of competition and demand volatility may also impact the supplier's decision for the retailers' financial stability and in [Henninger, A and Mashatan, A. (2021)], [Chang, S.E., et al. (2019)] technology cannot be used in full potential various forms of loss occurrences in supply chain finance operation risk, [Wang, R., et al. (2019)], [Nakasumi, M. (2017, July)] and [Dong, G., et al. (2021)], [Chang, S. E., et al.] has a tax rate and a tax deduction ratio for reducing carbon emissions, both of which have an effect on retail prices. [Razavian, E., et al. (2021)] affect the functioning of the supply chain, bankruptcy cost is relatively high in [Li, Y., et al. (2022)], [Yan, N and He, X. (2020)] and unfeasibility in work condition occurs in [Nguyen, Q.K. (2016, November)]. Moreover, there is a need for improvements in trade finance stability, secure operation, reducing carbon emissions, and better functioning of the supply chain. So, this proposed deep blockchain-enabled security that provides better enhancements in the trade finance market.

3. Deep Blockchain-Enabled Security Enhancement in Trade Finance

Innovation in trading and finance is required to improve trading security since crypto trading also improves trading security, many methods based on crypto trading have been developed in the past. The existing strategies have no concept of blockchain-enabled cryptographic trading security thus the data block is altered due to the unavailability of the security in the trading Thu the bandwidth of the transaction decreases due to the financial problem in the cryptographic trading there is minimum security with the trading information which shall get by the hackers thus the new technique is introduced here to enhance the security of the trading financial system. Although, the existing techniques are having issues in security, finance, and trade thus in producing the security in trading and finance, therefore, has to provide efficient processing of

security and trading with a blockchain-enabled stock trading financial innovation is evolved

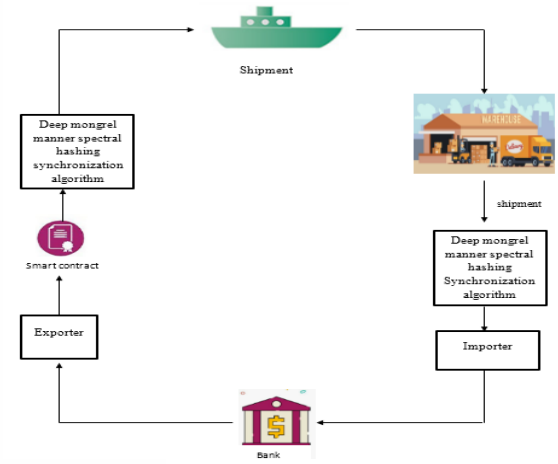

Fig 1. Architecture of the proposed blockchain-enabled crypto trading in security and finance

The proposed model for blockchain-enabled crypto trading has been shown in figure 1, in which the smart contract is made in the trading for security reasons thus the trading is secured with the hashing function in the cryptographic technique. The proposed system starts the trading with the exporter in the blockchain in which the exporter enables the trade subject to send it with a safe step thus the smart contract is important in the trade which ensures the trader with the safety in the trading with the preprocessed contract thus the input is given as the hashing function by the deep mongrel manner spectral hashing thus there the hashing takes place in the receiver end thus the importer has the hashing key thereby the information from the exporter has been securely transferred to the importer and then the banking is carried out between the traders.

3.1 Blockchain-enabled crypto trading

The blockchain crypto-trading system was created by combining three independent subsystems. The key components are (i) blockchain subsystem, (ii) smart metering subsystem, and (iii) trading platform subsystem. The smart grid-based energy transmission and distribution system is added to these parts thus each subsystem plays a distinct function. The blockchain's subsystem is responsible for the production of tokens as well as their acquisition, exchange, and circulation.

The smart metering subsystem is an Internet of Things (IoT) system that serves as both a physical interface between the first part of the crypto-trading system and the energy transmission grid

It is overseen by the Transmission and Distribution system operators and is a certified reference for monitoring energy production and consumption.

The trading platform subsystem enables the trade of cryptocurrency trading tokens using a blockchain crypto-trading system with AI techniques designed to make trading simpler and more successful.

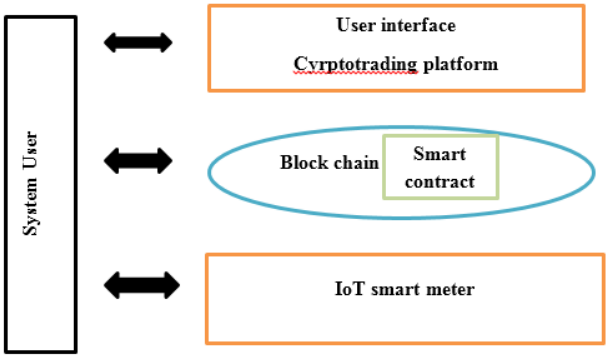

Fig 2. Subsystem in crypto trading

Figure 2 shows the three subsystems of crypto trading in which each subsystem is thought of as a separate entity with its own "actors," who in turn are thought of as actors in other subsystems. One actor of the blockchain subsystem is, for instance, the smart metering subsystem. The blockchain subsystem, which serves as the decentralized brain of the crypto-trading system, is the primary emphasis of this work. The Crypto-Trading project assists in facilitating the transition from an energy paradigm with centralized production to one with decentralized and intelligent production and distribution that is suited to local needs and intended to meet local consumption. The current "inadequacy of the regional energy distribution infrastructure concerning the new needs resulting from the advent of dispersed production" is something that crypto-trading intends to address. The benefits of blockchain in financial trading include transparent pricing, new alternative markets, faster payment processing, and immutable transaction recording. People may now trade at lower costs and faster thanks to blockchain ledger technology. Trade Block offers institutional trading platforms for digital currencies. The business creates individualized bitcoin trading platforms with tools for trade execution, market analytics, and an index protected by blockchain ledger technology. Blockchain intends to enable the sharing and recording of digital material without the need for editing. Because blockchains serve as the foundation for immutable ledgers, or records of transactions that cannot be modified, erased, or destroyed, they are also known as Distributed Ledger Technology (DLT). The objective of

the blockchain will enable one to know the subsystem of the blockchain to detect competing activities and direct components of the decision-making process objective are important aspects of the blockchain subsystem which is given in the next subsection as follows.

3.1.1 Objective of the blockchain subsystem

The blockchain subsystem's goal is to offer a decentralized framework for producing and administering Crypto-Trading Energy Tokens. The Crypto Trading Token (CTT) is the primary component of the blockchain subsystem and binds the blockchain subsystem to all of its duties and activities. All entities that engage with the blockchain subsystem are considered the actors in this subsystem. The System Administrator, the Prosumer, the Smart Meter, and the Trading Platform are all components of the Trading Platform.

3.1.1.1 System User

The CTT contract's specifications are determined by the administrator. It is recognized by an Ethereum address. System users are computers or programs that make API calls to resources that a business manager owns or manages.

3.1.1.2 Prosumer

The ability to buy and sell CTT tokens which are connected to a list of Smart Meters that will communicate with the token content. Consequently, an individual or community is in charge of using or creating electrical energy. It has a unique Ethereum address.

3.1.1.3 IoT Smart Meter

A Prosumer-connected IoT device is a device when the production or consumption of energy reaches a predetermined threshold or when the prosumer triggers it, it measures both and sends messages to the CTT. It will be recognized by its Ethereum address and is aware of the Prosumer and thus owns it by their address.

3.1.1.4 Trading

Several applications that is decentralized and offer facilities for exchanging energy tokens as well as a user interface to make it easier to browse prosumer accounts. Trading is the practice of buying and selling financial instruments to make money. These instruments consist of a range of assets that have been assigned a changing financial value for you to guess which way they will go. It's possible that in heard of stocks, shares, and funds.

3.1.1.5 Time complexity

Time complexity is a measure of the amount of time an algorithm takes to complete its execution as a function of the input size. In cryptography, time complexity is an important consideration because cryptographic schemes are efficient enough to handle encryption, decryption, key generation, and other operations within reasonable timeframes. Furthermore, in cryptography schemes, the commonly used polynomial multiplication has the major problem of time complexity during encryption. The time of consumption is high in their fully homomorphic encryption algorithms in polynomial multiplication. By using the blockchain-enabled crypto trading in trade application with a deep mongrel-manner spectral hashing synchronization algorithm the time complexity is less when compared to [Song, M., et al. (2021)].

3.2 Blockchain-enabled crypto trading in financial innovation

Blockchain technology is probably going to be a major driver of financial sector innovation in the future. It enables the generation of unalterable, all network users have access to transaction records. A blockchain database is composed of several blocks that are "chained" together by references in each block to the one before it. One or more transactions, which are effectively modifications to the listed owner of assets, are recorded in each block. By having participants in the blockchain network certify transactions as genuine, new blocks are added to the existing chain.

Smart contracts are decentralized computer programs that receive messages from smart meters and trading platforms, stored and executed via blockchain technology. The blockchain makes all previous data, including transactions involving energy, publicly accessible.

The tradable energy unit has a token. With the use of blockchain technology, every consumer buys and sells tokens whenever they want, and it is impossible to sell the same energy token again. They trade money for energy using either the cryptocurrency linked to the blockchain system or another unique token with its worth. The users' blockchain accounts contain a record of the currency's availability. When a prosumer needs something, the trading system sends messages to a smart contract. The trading system notifies the relevant smart contract whenever a prosumer sells a particular amount of energy, and the smart contract then transfers the corresponding amount of energy tokens to the buyer's energy account. The exchange of energy tokens stops the sale of energy twice in this fashion. Blocks are built on top of the hash values in the blockchain, which uses them to keep the chain connected and immutable. A

block is a collection of authorized transactions with a hash pointing to the block before it and a time stamp. A network protocol called "smart contracts" enables trustworthy transactions to be completed without the involvement of a third party. Smart contracts are designed to facilitate, verify, or enforce contract discussions or performance.

The blockchain-enabled crypto trading for security enhances security with the usage of several hashing functions which provide security in trading thus crypto trading enables the concept of trading with several advantages the smart contract helps the consumer and the seller to be aware of the trade thus the usage of specialized tokens also has greater advantages over the blockchain-enabled crypto trading. Security has unquestionably improved as a result of the exchange's greater transparency. Every one may see that a deal has been processed, and carried out, or that the exporter has received payment. Because it is nearly hard to edit or delete something after it has been saved on the blockchain.

3.2.1 Smart contract

Each prosumer's energy availability is listed in a unique smart contract that serves as a representation of their energy account. They are added to the blockchain in the form of program codes (for example, a Bitcoin transaction) after being signed by all parties. Smart contracts are made up of scenario-response procedural rules and logic. In other words, they are decentralized and trustworthy shared codes stored on a blockchain. A smart contract has several predefined states and transition rules, scenarios that cause the contract to be executed such as when a specific time or event occurs, answers in a specific scenario, etc. To automate contract execution on behalf of the signatories, the parties signing a contract should agree on the contract's provisions, breach conditions, responsibility for the breach, and external verification data sources. This agreement should then be implemented as a smart contract on the blockchain. Central organizations have no control over the entire process. The smart contracts are often recorded in the blockchain after being propagated via the P2P network and verified by the nodes. The blockchain keeps track of smart contracts' current status in real time and executes them when specified trigger conditions are satisfied. Implementations of blockchain technology will probably be complemented by smart contracts to reach their full potential. Legal agreements known as "smart contracts" are written in computer code and are automatically carried out when predetermined criteria are met. Distributed ledgers can be enhanced with smart contracts such that they self-execute based on data contained in the ledger. This will enable procedures that presently require manual involvement to be automated.

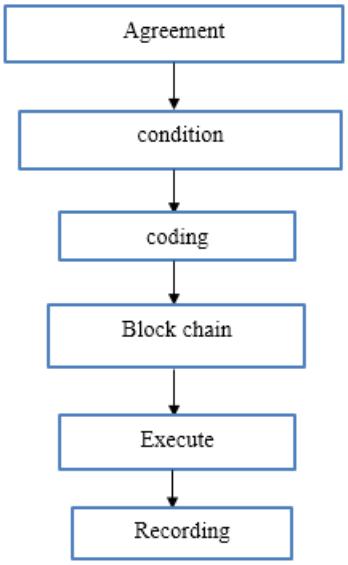

Fig 3. Smart contracts in the blockchain

Figure 3 explains the blockchain-enabled smart contract with various steps each step exhibits the characteristics and enhancement of the smart contract. Smart contract receives and accept assets. The smart contract automates clearing and settlement. The undisputed ownership is obtained by the smart contract. Because of its programmable protocol, the smart contract enables the implementation and automation of contract terms. The blockchain platform can be used to deploy smart contracts, which can then be used to activate code execution through event triggers for a variety of business applications. Business activities between international trade players may be regarded as an appropriate use for the smart contract. When opposed to the common use of paper contracts and trade documents in international trade, a smart contract deployed on the blockchain provides a seamless solution that might avoid tampering and counterfeiting. Standard L/C procedures mainly rely on centralized corporate activities.

3.2.2 Deep mongrel-manner spectral hashing synchronization algorithm

The deep mongrel manner spectral hashing has the training data as the input to the hashing they provide the synchronization algorithm in which the vector-valued

tree parity machine (VVTPM) is utilized by two parties, and the VVTPM synchronizes weights with the algorithm. The deep mongrel-manner spectral hashing synchronization predicts the security in the trade finance the input of training data B and parameters such as P, R, and Ra are also given thus it randomly initializes the hashing process and then computes and generates the matrices and laplacian graph then obtain the cross manner binary codes using hashing function and finally, train modality specific hashing function thereby complete the algorithm process and the output obtain is manner specific hashing functions.

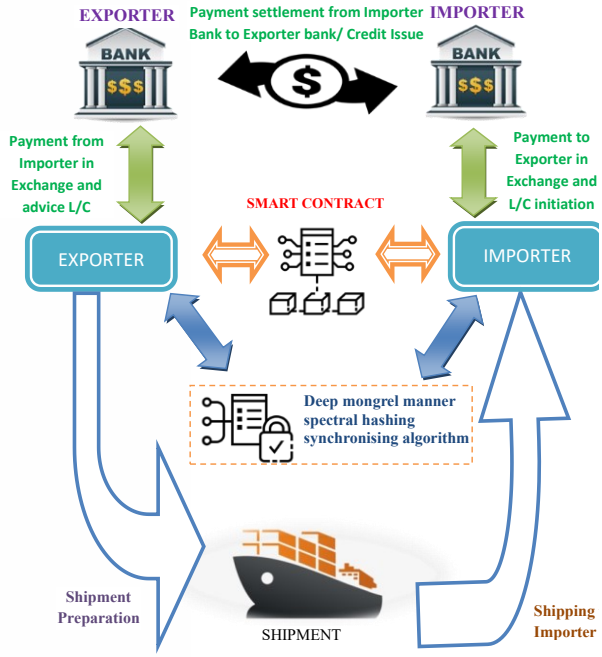

Fig 4. Hardware Architecture of Blockchain enabled crypto trading in security and finance.

Figure 4 depicts the deep mongrel-manner spectral hashing synchronization algorithm utilized hardware architecture of Blockchain-enabled crypto trading in security and finance. Blockchain-enabled crypto trading in security and finance typically involves a combination of hardware and software components. The hardware architecture for such systems may vary based on the specific requirements of the trading platform and the scale of operations. Application logic for the trading platform's servers, such as order matching, trade execution, and user management databases that hold user account information, trade history, and other pertinent data are hosted on servers. Servers or nodes in the blockchain network are mentioned here. They keep a copy of the blockchain and verify transactions based on the agreed-upon consensus guidelines. servers in charge of gathering and disseminating real-time market information, including price feeds from numerous exchanges. To ensure effective utilization and high availability, load balancers split incoming network traffic among several application servers. Defend the network's infrastructure from unapproved access and online dangers. Hardware Security Modules (HSMs) devices provide cryptographic key management and protection, ensuring the security of sensitive data, such as private keys used for signing transactions. It is essential to make sure that the hardware architecture is well-designed to satisfy the requirements of efficient and safe crypto trading in the security and financial sectors.

Algorithm: Deep mongrel-manner spectral hashing synchronization

Input: *Training data* $B = \{bi\}_{i=1}^{M}$*; code length L; parameters* $P, R, Ra, \lambda 1, \lambda 2, \alpha, \gamma 1, \gamma 2, K, L, N$

Output: *Manner-specific hashing functions* $\{F^n\}_{n=1}^{N} W^k$

/ I - Anchor Graph * /*

{

Initialize W^{K^R} (W^{K^S}) *randomly for k=1,….,K*

Learn *anchor sets for modalities*

Do $W^R \neq w^S$

Compute *the expanded data-to-anchor affinity matrices* $\{\hat{Z}^n\}_{n=1}^{N}$ *fork from 1 to k and I from 1 to n*

Generate X_i^k *randomly*

Compute *the Laplacian graphs* $\{L^n\}_{n=1}^{N}$

/* II - Maximized Correlation Cross-manner Binary Codes * /

end

Obtain *cross-manner binary codes B using Algo. 2*

/ III - Hashing functions * /*

$$h^{k^{R/S}} \leftarrow 1/\sqrt{N} \begin{bmatrix} x_1^k & . & W_1^{K^{R/S}} \\ x_2^k & . & W_2^{K^{R/S}} \\ x_n^k & . & W_n^{K^{R/S}} \end{bmatrix}$$

$$\sigma^{k^{R/S}} \leftarrow Sgn(h^{k^{R/S}})$$

end

Train *modality-specific hashing functions* $\{Fn\}_{n=1}^{N}$ *with the objective function*

$$\tau^{R/S} \leftarrow \sigma^{1^{R/S}} \odot \sigma^{2^{R/S}} \odot \ldots \odot \sigma^{K^{R/S}}$$

for i from 1 to n and k from 1 to k

if $\tau^{i^R} = \tau^{i^S}$ *then*

$W_i^{k^R} \leftarrow$ *Learning rule* $(W_i^{k^R})$ *where i satisfies* $\tau^{i^R} = \sigma_i^{k^R}$
$W_i^{k^S} \leftarrow$ *Learning rule* $(W_i^{k^S})$ *where i satisfies* $\tau^{i^S} = \sigma_i^{k^S}$
end
end
end
end
output return $\{F^n\}_{n=1}^N W^k$
}

The algorithm thus initialize $\boldsymbol{W^{K^R}}$ $(\boldsymbol{W^{K^S}})$ in which the comment is given to the system thus it generates the output in the deep mongrel manner spectral hashing synchronization which enable the output in the synchronized form which is due to the commenting in the algorithm thus the output obtained is of return with the set function which is given by the modality-specific hashing function with the objective function.

Overall, Deep blockchain-enabled security enhancement in trade finance has been presented to generate the enhancement of security in trade finance by smart contract and hashing codes, and the security in financial innovation is further improved by Deep mongrel-manner spectral hashing synchronization algorithm in which the specific hashing function is used for the innovation in finance thus there is the enhancement of security in trade finance. The result and discussion of the proposed system and the comparison of the proposed with the existing system are mentioned in the following section.

4. Result and Discussion

This section includes a full analysis of the implementation outcomes, as well as information on how well the suggested system performs and a comparison section to make sure the suggested method is effective is applicable for the crypto trading security and financial innovation by using the blockchain. The results obtained from the proposed approach have been provided in this section. The results demonstrated that the proposed approach effectively solved the security issues and the suggested approach's effectiveness is further demonstrated by comparison with other current approaches such as the Data Encryption Standard (DES), 3 DES, and Advanced Encryption Standard (AES) [Maqsood, F., et al. (2021)], [Hamouda, B.E.H.H. (2020)].

4.1 Dataset

Trade Credit and Financing Costs is the database used which incorporates recorded details of the times of collection and settlement [https://www.kaggle.com/datasets/frankmollard/trade-credit-and-financing-costs]. Based on accounting data taken from financial statements of companies in Belgium, France, Germany, Italy, Poland, Portugal, Spain, and Turkey, this database consists of indicators of Days Sales Outstanding (DSO) and Days Payable Outstanding (DPO), used as agents for Customer and Supplier Payment Periods. Organize the data by country, industry, size, and year. Statistics distributions and the weighted average are presented for the data which is accessible as of 2000.

4.2 Performance comparison

Different performance parameters of the cryptographic algorithms such as throughput, times consumption of encryption and decryption process, and key generation are compared with the proposed algorithm. Also, time complexity in polynomial multiplication results are compared with existing algorithms. The results with better and enhanced performances are explained in detail in this section.

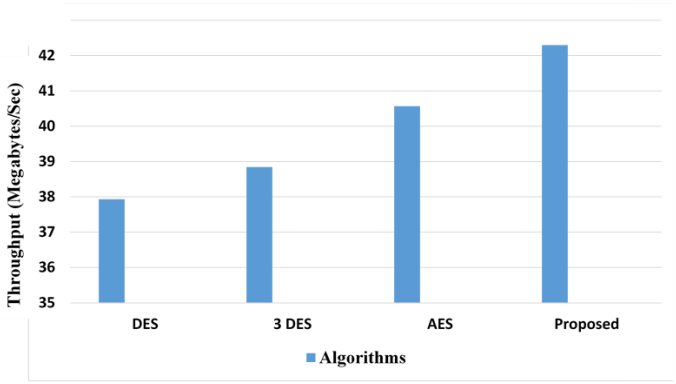

Fig 5. Comparison of the proposed algorithm for its throughput

Figure 5 explains the comparison of proposed on its throughput of the proposed system is found to be higher when compared with the other algorithms. The throughput of an encryption system is determined by dividing the total encrypted plaintext in Megabytes by the total encryption time for each approach. The result shows proposed algorithm throughput is highest when compared to the other existing algorithms. The throughput of the DES is about 37.93614 megabytes/seconds the, proposed has a throughput of

about 42.29831 megabytes/seconds which is considered as the highest throughput when compared with the other existing algorithms.

The comparison metrics for the various existing algorithms, the encryption time, decryption time, and key generation time are given such as DES, AES, and Rivest-Shamir-Adleman (RSA) algorithm as well as the proposed algorithm.

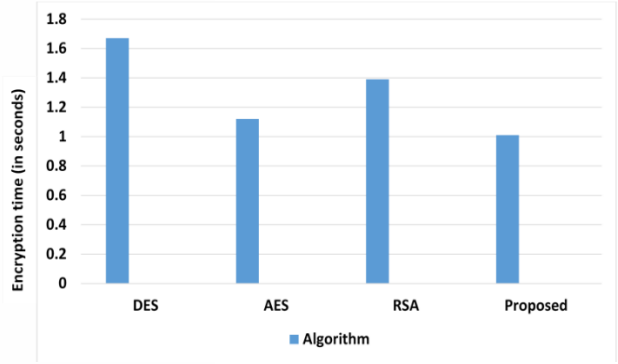

Fig 6. Comparison of the proposed algorithm for its encryption time

Figure 6 shows the comparison between the existing and proposed techniques in which the projected encryption time is short when compared to the other existing algorithms. This shows the proposed algorithm's efficiency The amount of time needed by any encryption function to transform plaintext into cipher text is known as the encryption time. Thus the proposal has a lower encryption time rate. The AES encryption time is 1.12 seconds and DES is about 1.67 seconds while the RSA has an encryption time of 1.39 the proposed has the lowest encryption time compared with the other existing algorithms which is given by 1.01 seconds.

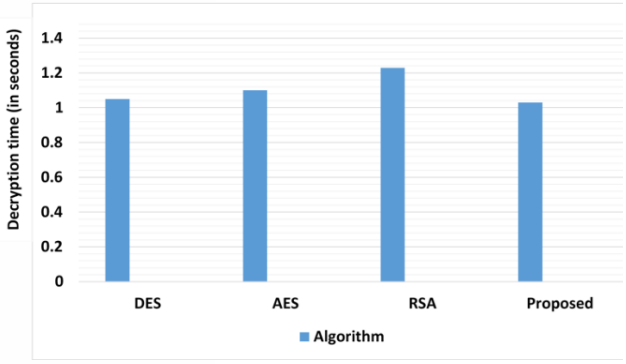

Fig 7: Comparison metrics of the proposed algorithm for its decryption time

Figure 7 depicts the proposed algorithm's comparison metrics for decryption time, where decryption time is the length of time required to convert plain text back into cypher text. Because the proposed has a shorter decryption time than the other existing methods, the proposed has large advantages in blockchain crypto trading. The decryption time of the AES and RES are 1.10 seconds and 1.23 seconds respectively. Thus, the proposed has a decryption rate of about 1.03 which is a low decryption time compared with the other existing algorithms.

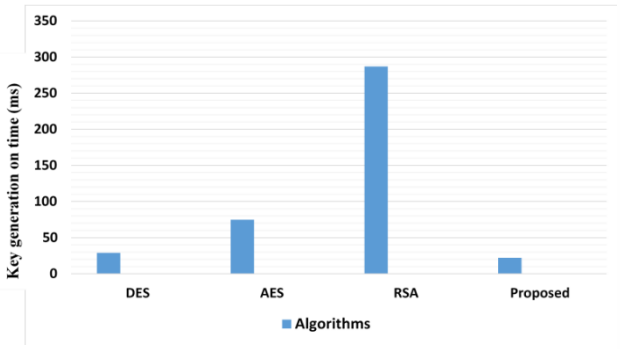

Fig 8. Comparison metrics of the proposed algorithm for its key generation time

Figure 8 compares the algorithm's key generation time to that of other known algorithms key creation time or the generation time is the amount of time necessary to generate keys using the key generation function. The comparison depicts that the proposed algorithm's time is short when compared to the existing approach, which has the largest advantage in terms of efficiency. The DES key generation time is 29ms which is greater than the proposed thus the proposed has a key generation time of about 22ms which is as low compared with the other algorithms thus it has the greater efficiency to generate the key in a short time. While the RSA has a key generation time of about 287ms which is the highest key generation time.

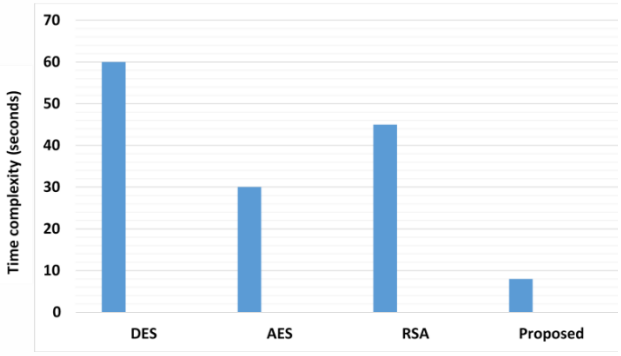

Fig 9: Comparison metrics of the proposed algorithm for its time complexity

Figure 9 illustrates the algorithm's time complexity with the time complexity of other well-known algorithms. The comparison shows that the proposed approach takes less time than the existing method, which has the greatest efficiency advantage. While comparing the existing models with the proposed approach, the existing method AES has a time complexity of about 30s and RSA has a time complexity of about 45s. The proposed method has a time complexity of about 8s, which is low compared to the other because the time complexity of DES is 60s, which is more than the proposed method.

Table 2: Comparison of the proposed algorithm with existing algorithms

Algorithms	Encryption time (in seconds)	Decryption time (in seconds)	Key generating time (ms)	Time Complexity (in seconds)
DES	1.67	1.45	29	60
AES	1.12	1.10	75	30
RSA	1.39	1.23	287	45
Proposed	1.01	1.03	22	8

Table 2 displays the total time complexity of a cryptographic operation composed of encryption time, decryption time, and key generation time. From Table 2, known and planned algorithms such as DES, AES, and RSA time required for encryption, decryption, key generation, and time complexity response comparison [Maqsood, F., et al. (2017)], [Hamouda, B.E.H.H. (2020)]. From table 1, the suggested algorithm has the shortest encryption, decryption, and key generation times and faster time response [Pranav, P., et al. (2021)]. The proposed algorithm's encryption time is 1.01 seconds. and the existing algorithm provides an encryption time of 1.67,1.12 and 1.39 which is greater than the proposed algorithm thus the proposed algorithm has greater efficiency than the existing algorithms.

In polynomial multiplication, the time consumption of the proposed secure algorithm is depicted in figure 10, which clearly shows lower values in time complexity. Therefore, the time consumption in the process of encryption and decryption of algorithms is lowered by the proposed algorithm.

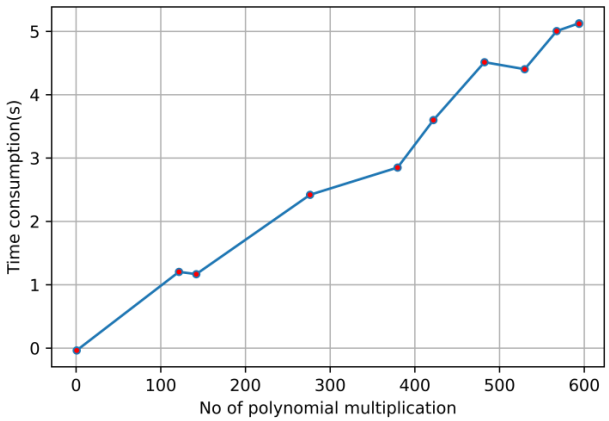

Figure 10: Response of time consumption in polynomial multiplication of the proposed algorithm

The response time is increased for an increase in polynomial multiplication. Although, the time complexity of the proposed algorithm provides low values when compared with [Song, M., et al. (2021)], only takes 5secs to compute 600 polynomial multiplications.

Overall the Blockchain-enabled crypto trading for security and financial innovation outperforms existing techniques such as DES, AES, and RSA with the best encryption, decryption, and key generation time of 1.01s, 1.03s, and 22 ms and achieved the time complexity with 8s and has a high throughput in the result is obtained.

5. Conclusion

The deep mongrel manner spectral hashing synchronization algorithm which uses the hashing function to solve security issues has been presented in this research to solve security problems and obtain financial innovation. As a result, by using crypto trading, security issues are minimized, and financial innovation is obtained by using blockchain in the trading system, thus the proposed experiment exhibits the increased rate of the throughput is obtained which is about 42.29831 Megabytes/second. When compared to other existing methods, the proposed has a shorter decryption, encryption, and key generation time, resulting in less

time complexity in the crypto trading process. The decryption time of the proposed is about 1.03 seconds which is lower when compared with the others thus due to these decreased rates of encryptions of about 1.01 seconds the proposed system is time-saving and beneficial in financial trading which serves as the best technique. The proposed method has a time complexity of about 8s, which is low compared to the other because the time complexity of DES is 60s, which is more than the proposed method. While blockchain is known for its transparency, trade finance often involves sensitive business information, and striking a balance between transparency and data privacy is challenging, especially when dealing with confidential trade-related data. In the future, explore advanced methods to maintain privacy with allowing relevant parties to access necessary trade finance information. Furthermore, techniques such as zero-knowledge proofs and multi-party computation can be integrated with blockchain to ensure the sensitive trade-related information which remains confidential.

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The study on interdependence analysis of product design attributes

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Abstract

With the improvement of customer awareness, companies have begun developing various diversified designs to meet customer needs. Make the designer face the challenge of multiple customer needs and then increase the difficulty of understanding. Taking a hair dryer as an example, this study applies Fuzzy Interpretive Structural Modeling (FISM) to analyze the interdependence of product design attributes. To effectively clarify the critical design factors and to describe the complex interdependence between each other. The research results show that by analyzing the logical sequence of attributes and transforming them into structured association diagrams and hierarchical diagrams. Structural association diagrams and hierarchical diagrams can help designers identify independent or dependent design factors. It is also possible to identify the interplay between key elements and desired attributes.

Keywords: Fuzzy theory, Interpretive structural modeling (ISM), Hair dryer, Interdependence.

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產品設計屬性互依關聯性分析之研究

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摘要

隨著顧客意識的提高，企業為滿足顧客需求，開始發展各種多元化與多樣化的設計。使得設計者將面臨多種顧客需求的挑戰，進而增加理解的困難。為有效釐清攫取關鍵性的設計因子，並能釐清彼此間複雜的互依關係。本研究以吹風機為例，應用模糊詮釋結構模式(Fuzzy Interpretive Structural Modeling, FISM)解析產品設計屬性之互依關聯性。研究結果顯示，經由解析屬性之邏輯順序並轉變為結構化關聯圖與階層圖，可協助設計者釐清獨立性或從屬性的設計因子，並可辨識關鍵性的要素以及需求屬性間互相影響關係。

關鍵詞： 模糊理論、詮釋結構模式、吹風機、互依關聯性。

6. 前言

隨著產品屬性需求越來越多樣化，產品需要不斷改進，產品屬性設計變更也越來越頻繁(Myrodia, Kris-tjansdottir, and Hvam, 2017)。設計者將面臨愈來愈多數量的設計資訊，設計屬性間的連結關係也變得十分複雜而不易理解(You, Kato, and Kitaoka, 1994)。產品項目越來越複雜，需求管理也越來越必要(Violante and Vezzetti, 2014)。Sage(1977)指出當顧客需求屬性越多或關聯程度較複雜時，設計者無法以直觀的方式處理。尤其在需求分析的階段，Tseng and Jiao(1998)也指出顧客的需求往往是不精確和模棱兩可的。顧客需求管理容易缺乏結構化的需求定義(Jiao and Chen, 2006)，且優先考慮顧客偏好的需求也是必要的(Griffin and Hauser, 1993)。由於模糊抽象與不明確的陳述需求，容易忽略顧客需求屬性間的互依性，以及對於屬性要求可能也有差別，因此在需求管理上，導致設計者很難判別複雜的產品設計相關需求訊息。例如以吹風機而言，當顧客考量攜帶或收納的情況時，就會加以考量產品的大小或重量，而產品的尺寸或重量也就會影響使用性或便利性。如此一來，即產生屬性之間相互影響而非各自獨立的情況，顧客衡量標準會因某項屬性獲得滿足而來取捨其他屬性。以至於在實際的情況，屬性之間仍會有相互牽制的現象。因此，在顧客需求之攫取與分析階段，若對顧客需求的缺乏理解力或是不精確的臆測，在後續之設計與製造階段中，將會對產品品質、前置時間與成本等造成嚴重負面的影響(Jiao and Chen, 2006)。

7. 文獻回顧

ISM 最早由 Warfield (1976)提出，原為社會系統工學(Social System Engineering)彙整訊息的一種結構化建模方法，為一制定管理決策的工具，以解決及分析複雜的情境問題(Senecal, Kalczynski, and Nantel, 2005)。You et al. (1994)指出 ISM 可將原始的個別資料轉換為有價值的資訊，並且釐清彼此的關係，這對於設計者而言，是展開正確的設計程序關

鍵因素之一。ISM 的獨特之處在於在屬性之間創建邏輯鏈接，這有助於形成系統或問題的可視化圖形，也就是透過繪製一結構性的圖形來表示屬性間的關係(Chen and Wu, 2010; Mandal and Deshmukh, 1994)，因為 ISM 通過結合計算、理論和概念能力來構建圖表(Narayanan, Sridharan, and Ram Kumar, 2019)，進而能清楚辨識屬性之間的相互影響關係。當存在不確定關係的因素影響主題時，運用此方法可以轉換為可理解和結構化的因素，方法的應用是有用的(Raut, Gardas, and Narkhede, 2019)。而與其他多準則決策(multi criteria decision making, MCDM)方法相比，ISM 不需要建立階層構造來研究因素之間的相互關係(Raut et al., 2019)。例如在層次分析法中(AHP)，沒有解決相互作用和間接影響(Zayed and Yaseen, 2021)。另外，在分析網絡法(ANP)的分析過程中，可能無法反映所有依賴關係，因為很難去除集群內可能會有的交互作用(Wu, 2008)。ISM 也不同於決策試驗和評估實驗室(DEMATEL)和社交網絡分析(SNA)的替代方法，因為 ISM 除了在復雜系統中建立關係之外，還需要優先考慮因素(Abuzeinab, Arif, and Qadri, 2017)，而且是一個需要相對較少數據量的強大工具(Panigrahi and Sahu, 2018)。ISM 不需要定量數據，且是通過構建影響系統的許多不同且直接相關的變量來準備模型，有助於分析變量之間的相互關係(Bouzon, Govindan, and Rodriguez, 2015)。ISM 方法有多種擴展並應用於各種領域，這些領域包括教育學、行政學、社會學、心理學等(Warfield, 1982)。例如 Ravi and Shankar(2005)的研究應用 ISM 來分析汽車工業供應鍊中逆向物流之阻礙因素間的交互關係，以管理觀點確認因素間的層級關係，並以結構化自我交互矩陣建立成對因素間的關係，作為設定要素層級與有向圖之依據。Jiang et al. (2018)使用 ISM 和模糊分析網絡(FANP)來識別風險因素，並計算北極航運戰略聯盟的風險，可以強調應該關注的風險因素。而另一項研究也使用 ISM 方法來確定可持續生產系統的關鍵成功因素(CSF)(Kota, et al., 2021)。Menon and Ravi (2021)透過 ISM 研究電子行業供應鏈管理的問題。對於技術領域，ISM 通過新產品開發(NPD)整合來評估新產品的各種技術(Lee, Kang and Chang, 2011)。

再者，將 ISM 結合模糊理論(fuzzy set theory)的計算方式，能有效處理人類思想和表達決策的模糊性(Tseng, 2013)。這是由於人類主觀判斷的不確定性和偏見以及意識的缺乏，現實生活事件的視角可能會發生偏差(Lopez et al., 2021)。而模糊理論可以克服這些問題並提高決策者判斷的準確性(Bari et al., 2022; Karmaker et al., 2021)。模糊集合理論(fuzzy set theory)是由札德(L. A. Zadeh)於 1965 年提出，此理論強調人類之思考推理及對週遭事物之感知，均充滿相當之模糊性(Zadeh, 1965)。而且在不確定性與複雜性的影響之下，唯有同時考慮模糊性的特性，方能正確地衡量目標達成的狀況(Bellman and Zadeh, 1970)。模糊集理論在處理人類思想和表達決策的模糊性很有幫助(Tseng, 2013)。ISM 與模糊集的集成為決策者提供了靈活性，以進一步了解一個標準對另一個標準的影響程度，這在早期僅以二進制(0, 1)數字的形式存在(Khatwani, Singh, Trivedi , & Chauhan, 2015)。0 代表沒有影響，1 代表有影響。因此，無論影響程度如何，無論是低、高還是非常高，決策者都只能選擇 0 或 1。而 FISM 方法解決了這個問題，並提供更全面的靈活性，可以使用模糊數來表達影響性。在這方法中，不再僅是從二進制的角度來識別變量之間的關係，而是根據 0 和 1 之

間的數值範圍對連接進行排序，例如 0、0.1、0.3、0.5、0.7、0.9 和 1 等。模糊集理論擴展集合論的經典概念，並已廣泛用於解決現實生活中的模糊問題，由於該工具能夠評估從專家或調查參與者那裡獲得的主觀判斷，因此引起了從業者和學術界的廣泛關注。至於有關 FISM 技術的應用領域，例如 Tseng(2013)應用 FISM 來解決分析衡量可持續生產指標(SPI)，所提出的標準被分類為一個層次結構，並根據其驅動力和依賴力排列在圖表上的視覺象限中，如此透過圖示和層次結構可以協助管理人員進行與改善公司環境活動相關的戰略規劃。Valmohammadi and Dashti (2016)也是應用 FISM 來識別和突顯這些電子商務阻礙之間的內在相互作用。以上說明 ISM 與 FISM 技術的多重面向應用，確實能釐清關鍵性屬性間的結構化關係，輔助設計者進行設計規劃，以利後續產品設計與發展。

8. 研究方法

ISM 是利用圖形理論(graph theory)與階層有向圖(hierarchical digraph)來描述分析目標屬性之次序邏輯關係，如此可將抽象化的屬性順序轉變為具體化與全面化的關聯構造階層圖，能有效釐清屬性間互相影響的關係(Jharkharia and Shankar 2004)。而加入模糊理論能提高結果的準確度(Kwong and Bai, 2002; Govindan, Diabat, and Madan Shankar, 2015)。FISM 實施步驟如下：

3.1 建立相關矩陣

判別屬性 ei 對 ej 的影響情況。式(1)中 ei 為第 i 個屬性，ej 為第 j 個屬性，π ij 為兩屬性間的相互關係。問卷調查表是採用模糊語意尺度如表 1 與圖 1 所示，且使用三角模糊數予以量化。解模糊化計算根據 Lee and Li (1988)，當三角模糊數 Ã=(l, m, u) 時，解模糊後之數值如式(2)。接著，利用取門檻值≧0.5 的方式，將解模糊化的數值(0～1)轉換為明晰值(πij=1 為有影響，π ij=0 為無影響)。

$$D = \begin{array}{c} \\ e_1 \\ e_2 \\ \vdots \\ e_m \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & \cdots & e_n \end{array} \\ \begin{bmatrix} 0 & \pi_{12} & \cdots & \pi_{1n} \\ \pi_{21} & 0 & \cdots & \pi_{2n} \\ \vdots & \vdots & 0 & \vdots \\ \pi_{m1} & \pi_{m2} & \cdots & 0 \end{bmatrix} \end{array} \tag{1}$$

$$DF = \frac{((u_i - l_i) + (m_i - l_i))}{3} \approx \frac{(l + m + u)}{3} \tag{2}$$

表 1. 問卷使用之模糊語意尺度。

語意	尺度
極高度重要	(0.75, 1.0, 1.0)
高度重要	(0.5, 0.75, 1.0)
中度重要	(0.25, 0.5, 0.75)
低度重要	(0, 0.25, 0.5)
極低度重要	(0, 0, 0.25)

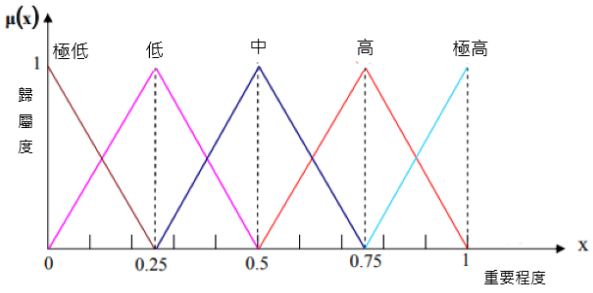

圖 1. 五個等級語意變數之隸屬函數圖。

3.2 計算關係矩陣

將相關矩陣 D 與單位矩陣 I 相加如式(3)。

$$M = D + I \tag{3}$$

3.3 文獻探討計算可達矩陣

利用式(4)及布林代數運算法，將關係矩陣 M 轉換成可達矩陣 M*。當達到收斂，便可求得可達矩陣 M*。

$$M^* = M^k = M^{k+1} \quad k > 1 \tag{4}$$

3.4 將可達矩陣 M*轉換為階層矩陣

在可達矩陣 M*中的第 i 項元素，以直向計算其關係值為 1 者抽出，即為可達集合 R(ti)，如式(5)；而以橫向計算其關係矩陣值為 1 者抽出，即為先行集合 A(ti)，如式(6)；最後，依照式(7)判斷出兩集合的交集，即可找出關係架構的核心屬性，並藉此核心屬性建立出屬性間的相關圖。

$$R(t_i) = \{e_i | \ m^*_{ji} = 1\} \tag{5}$$

$$A(t_i) = \{e_i | \ m^*_{ij} = 1\} \tag{6}$$

$$R(t_i) \cap A(t_i) = R(t_i) \tag{7}$$

3.5 繪製結構關係圖

計算每一橫列與直行之總合數值，並計算每一個設計屬性之成對資料(D+R, D-R)為 XY 軸數值來繪製結構關係圖，其中 D 為影響力之傳送者角色，R 為影響力之接收者角色，(D+R)為關連程度，(D-R)為影響程度。

9. 結果與討論

本研究以吹風機為例，提出需求分析方法的實用性。研究中所分析之產品需求屬性根據 Chen and Chiang(2011)的研究調查結果，採用的屬性分別為：風嘴輔助配件(A1)、人為溫度控制(A2)、自動恆溫(A3)、電磁波防護(A4)、易於收納(A5)、重量輕(A6)、款式的變化(A7)、顏色搭配(A8)、質感(A9)、風量(A10)、噪音量(A11)、省電(A12)、節能標章(A13)、絕緣性佳(A14)、握柄易握防滑(A15)、機體過熱自動斷電(A16)、耐熱性佳(A17)、堅固耐用(A18)等 18 項。

接著，研究委請 4 位專家進行問卷調查，4 位專家分別為家電相關產業設計師 2 位(包含機構設計師與研發人員)與產品設計相關系所具有實務經驗教育者 2 位。問卷採取封閉式評分量表，使用表 1 之模糊語意尺度進行各自評分，而後針對屬性的模糊評估值加以整合並加上單位矩陣 I，再經由解模糊化計算如表 2，且依據布林代數運算方法與矩陣連續乘積，當關係矩陣(M)達收斂，即為可達矩陣 M*(表 3)。而後根據可達矩陣 M*(表 3)可定義設計屬性之可達集合 R(t_i)、先行集合 A(t_i)與強相關集合 R∩A，可達矩陣中直行為可達集合，橫列為先行集合。

例如從表 3 中可得知當 A1 可直接或間接到達 A1、A5、A6、A7、A9、A10、A11、A12、A13、A15、A17、A18 等屬性；先行要素為 A1；而強相關集合結果顯示 A1 為強相關集合(R∩A)關係架構的核心屬性；當 A2 可直接或間接到達 A2、A3、A10、A11、A12、A13、A16、A17 等屬性；先行要素為 A2、A3、A16；而強相關集合結果顯示 A2、A3、A16 為強相關集合(R∩A)關係架構的核心屬性；當 A3 可直接或間接到達 A2、A3、A10、A11、A12、A13、A16、A17 等屬性；先行要素為 A2、A3、A16；而強相關集合結果顯示 A2、A3、A16 為強相關集合(R∩A)關係架構的核心屬性，以此類推整理 A1 至 A18 屬性之可達集合 R(ti)、先行集合 A(ti)與強相關集合 R∩A 如表 4 所示。

表 2. 解模糊化計算結果。

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18
A1	1.00	0.08	0.08	0.08	0.63	0.71	0.52	0.19	0.19	0.71	0.63	0.25	0.19	0.13	0.08	0.19	0.19	0.25
A2	0.08	1.00	0.50	0.08	0.08	0.08	0.08	0.08	0.08	0.67	0.67	0.71	0.29	0.25	0.08	0.71	0.71	0.29
A3	0.08	0.46	1.00	0.19	0.08	0.19	0.19	0.08	0.19	0.67	0.25	0.71	0.71	0.25	0.08	0.71	0.46	0.29
A4	0.08	0.08	0.08	1.00	0.60	0.25	0.71	0.08	0.25	0.08	0.08	0.08	0.08	0.08	0.50	0.08	0.08	0.25
A5	0.08	0.08	0.08	0.08	1.00	0.08	0.46	0.08	0.25	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.71
A6	0.08	0.08	0.08	0.08	0.42	1.00	0.25	0.08	0.42	0.08	0.42	0.08	0.08	0.08	0.50	0.08	0.08	0.71
A7	0.08	0.25	0.08	0.08	0.71	0.63	1.00	0.50	0.71	0.42	0.42	0.08	0.08	0.08	0.67	0.08	0.08	0.71
A8	0.08	0.08	0.08	0.08	0.08	0.08	0.29	1.00	0.71	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
A9	0.08	0.08	0.08	0.08	0.08	0.42	0.29	0.46	1.00	0.08	0.08	0.08	0.08	0.08	0.19	0.08	0.08	0.60
A10	0.25	0.08	0.08	0.42	0.08	0.08	0.08	0.08	0.08	1.00	0.71	0.88	0.71	0.08	0.08	0.50	0.08	0.08
A11	0.08	0.08	0.08	0.08	0.08	0.08	0.25	0.08	0.08	0.25	1.00	0.08	0.50	0.08	0.08	0.08	0.08	0.08
A12	0.08	0.08	0.25	0.08	0.08	0.08	0.08	0.08	0.08	0.25	0.08	1.00	0.71	0.08	0.08	0.08	0.08	0.08
A13	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.25	0.29	0.25	1.00	0.08	0.08	0.08	0.08	0.08
A14	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	1.00	0.08	0.08	0.08	0.50
A15	0.08	0.08	0.08	0.08	0.58	0.63	0.79	0.19	0.63	0.08	0.08	0.08	0.08	0.08	1.00	0.08	0.08	0.67
A16	0.08	0.71	0.67	0.25	0.08	0.25	0.19	0.08	0.08	0.08	0.08	0.25	0.25	0.08	0.08	1.00	0.19	0.08
A17	0.42	0.42	0.42	0.08	0.08	0.50	0.08	0.08	0.08	0.42	0.08	0.08	0.08	0.08	0.08	0.50	1.00	0.50
A18	0.42	0.08	0.42	0.08	0.08	0.71	0.42	0.08	0.58	0.42	0.08	0.08	0.08	0.50	0.08	0.50	0.83	1.00

接著，根據 FISM 分析所得設計屬性的 D 值(驅動力)與 R 值(附屬力)，可繪製驅動與附屬力分析圖如圖 2 所示，將設計屬性進行分類管理(Mandal and Deshmukh, 1994)，區分類別特性如下：

(1) 自主性要素(autonomous elements)：絕緣性佳(A14)屬於自主性要素。此類特點是附屬力 D 與驅動力 R 皆相當薄弱，自主性要素鮮少與其他要素有所互動。而顏色搭配(A8)介於自主性要素與驅動性要素之間，風量(A10)介於自主性要素與附屬性要素之間。

(2) 附屬性要素素(dependent elements)：這類的要素其特點在於其附屬力 R 相當強，但驅動力 D 則相當薄弱，往往會在屬性階層的最上端。重量輕(A6)、質感(A9)、噪音量(A11)、省電(A12)、節能標章(A13)、耐熱性佳(A17)、堅固耐用(A18)屬於附屬性要素。

(3) 鏈結性要素素(linkage elements)：18 項屬性中較少屬於此鏈結性要素，易於收納(A5)剛好在區隔的中間點，同時在階層的中間層，所以將易於收納(A5)歸類在鏈結性要素。此類特點在於驅動力 D 與附屬力 R 皆相當強，鏈結性要素與其他要素之互動最多，往往置於屬性階層的中間層。

(4) 驅動性要素(driver elements)：風嘴輔助配件(A1)、人為溫度控制(A2)、自動恆溫(A3)、電磁波防護(A4)、款式的變化(A7)、握柄易握防滑(A15)、機體過熱自動斷電(A16)屬於驅動性要素。此類特點是驅動力 D 相當強，但附屬力 R 相當薄弱，具有很高的獨立性。因此，驅動性要素往往置於屬性階層的最下層，需要先被施行完成者。

表 3. 可達矩陣。

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	D	D+R	D-R
A1	1	0	0	0	1	1	1	0	1	1	1	1	1	0	1	0	1	1	12.0	13	11
A2	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	8.0	11	5
A3	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	8.0	11	5
A4	0	0	0	1	1	1	1	0	1	0	0	0	0	0	1	0	1	1	8.0	9	7
A5	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	1	5.0	10	0
A6	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	4.0	13	-5
A7	0	0	0	0	1	1	1	0	1	0	0	0	0	0	1	0	1	1	7.0	11	3
A8	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	1	5.0	6	4
A9	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	4.0	13	-5
A10	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	4.0	9	-1
A11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1.0	7	-5
A12	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2.0	8	-4
A13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1.0	8	-6
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1.0	2	0
A15	0	0	0	0	1	1	1	0	1	0	0	0	0	0	1	0	1	1	7.0	11	3
A16	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	0	8.0	11	5
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1.0	14	-12
A18	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	4.0	13	-5
R	1	3	3	1	5	9	4	1	9	5	6	6	7	1	4	3	13	9	5		

再者，繪製顧客需求之結構關係圖如圖 3 所示，為視覺化地詮釋所得之可到達矩陣，根據可到達矩陣中成對數值資料(R-C, R+C)(如表 3)繪製結構關係圖，以利釐清顧客需求之間的關係，也可了解每項屬性受支配或獨立的狀態，以及設計上的主要問題為風嘴輔助配件(A1)、人為溫度控制(A2)、自動恆溫(A3)、電磁波防護(A4)、款式的變化(A7)、顏色搭配(A8)、握柄易握防滑(A15)與機體過熱自動斷電(A16)，而重量輕(A6)、質感(A9)、風量(A10)、噪音量(A11)、省電(A12)、節能標章(A13)、耐熱性佳(A17)、堅固耐用(A18)為主要目標。此外，還可萃取出設計入口與設計出口。一般而言，設計入口之設計屬性與其他要素擁有最強之關係，相對的，設計出口之屬性與其他屬性則擁有最弱之關係，因此，設計入口是設計程序中最優先需被考慮的屬性，設計出口則是設計程序中最後施行的對象。此外，獨立的屬性亦可被確認出來。分析結果顯示設計入口的屬性分別是人為溫度控制(A2)、自動恆溫(A3)、款式的變化(A7)、顏色搭配(A8)、握柄易握防滑(A15)、機體過熱自動斷電(A16)、風嘴輔助配件(A1)與電磁波防護(A4)等 8 個項目；設計出口的屬性分別是噪音量易於收納(A5)、重量輕(A6)、質感(A9)、風量(A10)、(A11)、省電(A12)、節能標章(A13)、絕緣性佳(A14)、耐熱性佳(A17)、堅固耐用(A18)等 10 個項目，獨立的設計屬性為絕緣性佳(A14)。分析結果顯示屬性間複雜的相依關係與分

類，可以藉由找到最初主要的屬性予以簡化，此外滿足這些根本的屬性的實現，將有助於最終屬性的達成。

最後，根據屬性之可達集合與先行集合，建立階層矩陣(Hierarchical matrix)完成屬性之層級與影響關係圖如圖 4 所示。根據強相關集合 R∩A 對應可達集合(表 4)中的單一選項主要有 A11、A13、A14 與 A17，此四項為設計出口，接著從可達集合中剔除上述四項後，再對應的單一選項則有 A6、A9、A12 與 A18，再來則是 A5、A8 與 A10，下一階層為 A2、A3、A7、A15 與 A16，最後的設計入口即為 A1 與 A4。從圖 3 中可知道人為溫度控制(A2)、自動恆溫(A3)、握柄易握防滑(A15)、機體過熱自動斷電(A16)、風嘴輔助配件(A1)與電磁波防護(A4)、款式的變化(A7)與顏色搭配(A8)都是設計的主要問題，而這些問題又可以從圖 4 的設計階層中，清楚知道可以先從主要問題的風嘴輔助配件(A1)與電磁波防護(A4)來去構思吹風機需不需要風嘴輔助配件來增強風力以及增加電磁波的需求與增設的方式。尤其在目前吹風機產品中，一些基本規格例如風量、噪音量都無法再有新的突破之下，若先從這兩個問題點去思考，更是會影響後續的吹風機款式變化(A7)與風量(A10)的設計，而增加了風口部位的重量或長度，也需要考量握柄易握防滑(A15)等問題，而電磁波防護(A4)則是要再延伸考量增設在吹風機的部位，也影響了款式變化(A7)與重量。再來就可以去思考第二階層人為溫度控制(A2)、自動恆溫(A3)、機體過熱自動斷電(A16)等問題。此外，上述這些項目也可以在圖 2 中看到是屬於驅動性要素，驅動性要素往往置於屬性階層的最下層，需要優先考慮。如此設計入口從 A1 與 A4 此處著手，在面對所有看似都是關鍵問題的時候，似乎可以從圖 4 結構圖中找出的設計入口問題。本階段畫分出屬性之層級與影響關係圖的目的是為了讓設計師面對複雜的問題時，可以利用詮釋結構模式，先將腦中較為籠統、主觀或是抽象化的資訊重新排列，轉換為關聯結構圖，幫助設計師有條理的進行設計。

表 4. 需求屬性之可達集合 $R(t_i)$與先行集合 $A(t_i)$。

屬性	可達集合 R(Ci)	先行集合 A(Ci)	強相關集合 R∩A
A1	A1, A5, A6, A7, A9, A10, A11, A12, A13, A15, A17, A18	A1	A1
A2	A2, A3, A10, A11, A12, A13, A16, A17	A2, A3, A16	A2, A3, A16
A3	A2, A3, A10, A11, A12, A13, A16, A17	A2, A3, A16	A2, A3, A16
A4	A4, A5, A6, A7, A9, A15, A17, A18	A4	A4
A5	A5, A6, A9, A17, A18	A1, A4, A5, A7, A15	A5
A6	A6, A9, A17, A18	A1, A4, A5, A6, A7, A8, A9, A15, A18	A6, A9, A18
A7	A5, A6, A7, A9, A15, A17, A18	A1, A4, A7, A15	A7, A15
A8	A6, A8, A9, A17, A18	A8	A8

A9	A6, A9, A17, A18	A1, A4, A5, A6, A7, A8, A9, A15, A18	A6, A9, A18
A10	A10, A11, A12, A13	A1, A2, A3, A10, A16	A10
A11	A11	A1, A2, A3, A10, A11, A16	A11
A12	A12, A13	A1, A2, A3, A10, A12, A16	A12
A13	A13	A1, A2, A3, A10, A12, A13, A16	A13
A14	A14	A14	A14
A15	A5, A6, A7, A9, A15, A17, A18	A1, A4, A7, A15	A7, A15
A16	A2, A3, A10, A11, A12, A13, A16, A17	A2, A3, A16	A2, A3, A16
A17	A17	A1, A2, A3, A4, A5, A6, A7, A8, A9, A15, A16, A17, A18	A17
A18	A6, A9, A17, A18	A1, A4, A5, A6, A7, A8, A9, A15, A18	A6, A9, A18

10. 結果

有效釐清設計屬性關係是發展產品成功的關鍵因素之一。在產品發展的初始階段中，如何有效攫取關鍵性的顧客需求屬性，並能釐清彼此間複雜的互依關係至為重要。本研究以吹風機設計為例，運用模糊理論結合 ISM 技術，其目的在於釐清需求間的相依關係與邏輯順序。藉此結構化的關聯圖與階層圖，協助設計者辨識確認設計入口、設計出口與獨立變數，以及依據需求屬性之驅動力與附屬力，進行分類管理，可輔助設計者釐清獨立性或從屬性，並可辨識關鍵性的屬性，有助於說明屬性之間的組織次序性關係，以及整合個人意見、經驗、想法和動機對於將語言判斷轉化為模糊數字，有效處理人類思想和表達決策的模糊性。研究結果顯示 FISM 能有效協助設計者以整體性視覺化觀點理解設計屬性。本研究雖以吹風機作為施行案例，所提出之模式亦可應用於其他產品設計程序，以作為釐清屬性關係之設計策略。

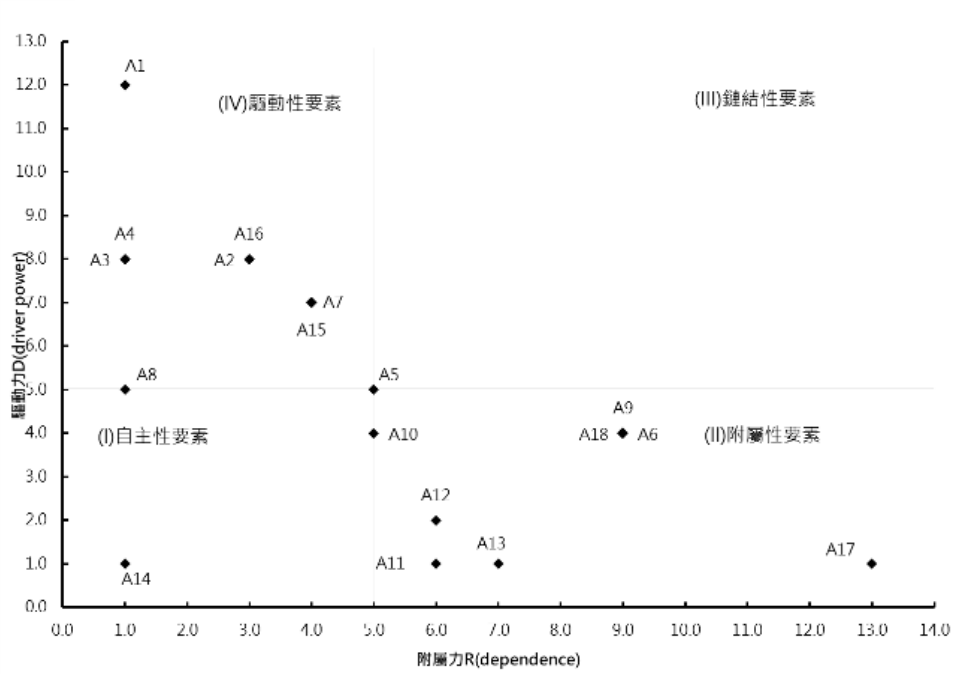

圖 2. 驅動與附屬力分析圖。

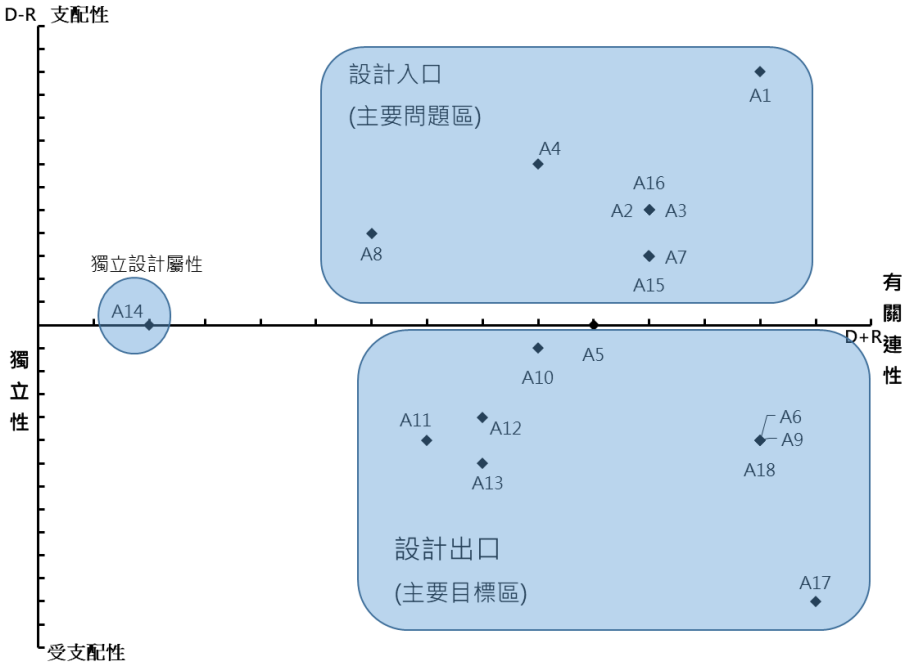

圖 3. 從可到達矩陣衍生之結構化關係圖。

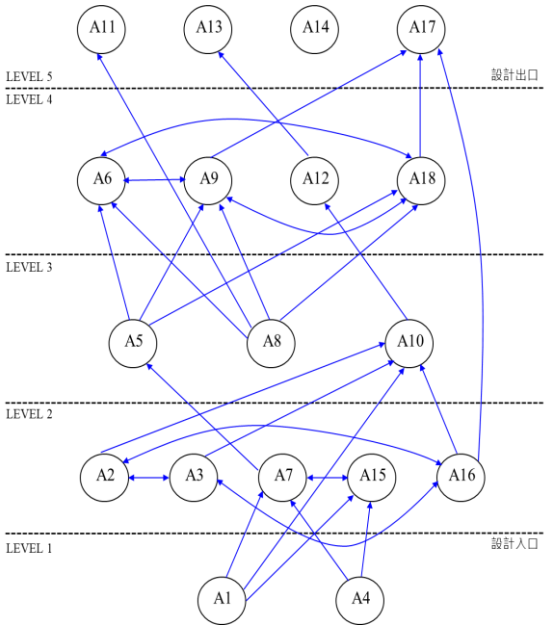

圖 4. 屬性之層級與影響關係圖。

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