Neutrosophic Fuzzy Neural Network Modelling and Current-Voltage Analysis for Forecasting Post-Surgery Risks

Mohammad Kanan[1], **Nadir Omer** [2 *], **Safaa S. I. Ismail** [3], **Rasha M. Abd El-Aziz** [4,5], **Ahmed I. Taloba**[4,6]

[1]Industrial Engineering Department, College of Engineering, University of Business and Technology, Jeddah 23847, Saudi Arabia

[2]Department of Information Systems, College of Computing and Information Technology, University of Bisha, Bisha 61922, P. O. Box 551, Saudi Arabia

[3]Department of Mathematics, Faculty of Science, New Valley University, El-Kharga 72511, Egypt, Egypt.

[4]Department of Computer Science, College of Science and Arts in Gurayat, Jouf University, Saudi Arabia.

[5]Computer Science Department, Faculty of Computers and Information Assiut University, Egypt.

[6]Information System Department, Faculty of Computers and Information, Assiut University, Assiut, Egypt.

Emails: m.kanan@ubt.edu.sa; nhamed@ub.edu.sa; safaasobhy1982@scinv.au.edu.eg; rashamahmoud@aun.edu.eg; Taloba@aun.edu.eg

Abstract

The electrical reaction of bioactive sites in the individual's body can be used to diagnose various disorders. Forecasts are made by examining the electric signal of the biologically active points onto patients. Measurements of the organ's present level and variations in the passive electrical characteristics at specific bioactive sites on the body were made to evaluate the influence on the organ. The study aims to create a Neutrosophic fuzzy neural network (NFNN) approach to forecast the probability of complications following surgery. The research investigates a neural network method for predicting hazards associated with post-surgical care. Examining the current-voltage features of the biologically active spots forms the basis for the characteristics of the risk classifiers. By looking at patients who had been given a diagnosis of a disease, the training, as well as verification samples, as well as verification samples were created. Patients with type 1 had successful operations, but type 2 patients experienced a variety of post-operative problems, and type 3 patients needed extra treatment. The created classifiers show an excellent ability to foresee severe circumstances during surgical therapy. The neutrosophic fuzzy neural network model may be more sophisticated and advanced compared to conventional fuzzy neural network models. It can help differentiate the proposed model from existing models and highlight its unique features and advantages. The results show that the proposed method beats existing ones in terms of accuracy, precision value, and speed of post-surgery risk prediction.

Keywords: Fuzzy neural network; neutrosophic sets; biologically active points; neutrosophic fuzzy neural network

1 introduction

Preoperative features, or preoperative and intraoperative factors, are frequently used in risk assessments for postoperative mortality or morbidity. Nevertheless, postoperative complications play a significant role in predicting postoperative mortality.[30] Consequently, patients' mortality risk would rise if they experienced postoperative problems. Surgery for the abdomen and pelvis frequently results in postoperative adhesions. Adhesions make future surgeries more difficult, prolonging recovery times and putting the patient in severe

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danger of harm to the bowels and other organs. They are significant contributors to persistent stomach pain, dyspareunia, and secondary infertility among women, the most common cause of female infertility overall, as well as a lifelong risk of small intestinal blockage. Although significant, adhesions harm patients' quality of life. Colorectal surgery postoperative problems are widely established, occurring at rates close to 30% of the time and making up almost 25% of all general surgical complications. While great effort has been put into recognizing and avoiding acute postoperative issues like wound infections, anastomotic leaks, and medical difficulties, considerably less has been spent on highlighting some of the frequent but ignored long-term alterations after colorectal surgery.[14]

The most common intracranial extra-cerebral tumors are meningioma.[36] When active therapy is required, the procedure of choice for many of these meningiomas is neurosurgical therapy targeted at full excision of the tumor with its Dura mater tail accompanied by clinicopathologic follow-up. This management controls a substantial percentage of diseases. However, there is a chance that postoperative problems from craniotomies will occur and negatively affect the patient's condition. Such problems cover a wide spectrum of negative effects, from little ones like nausea to serious ones requiring a second surgery, resulting in long-term cognitive abnormalities or even fatalities. In neurosurgery, in which the development of initial postsurgical problems is more exclusive regarding healthcare costs and is linked with noticeably greater mortality and morbidity contrasted with other surgical specialties, postoperative complications seem particularly noteworthy. The post-surgery complications are shown in Figure 1. Numerous studies have been carried out on the problem to determine risk factors, populations that are at risk, the seriousness of the complications, and the requirement for surgical or critical care organizations. Priorities of the most recent healthcare overhaul include lowering the early readmission rate following surgery.[22]

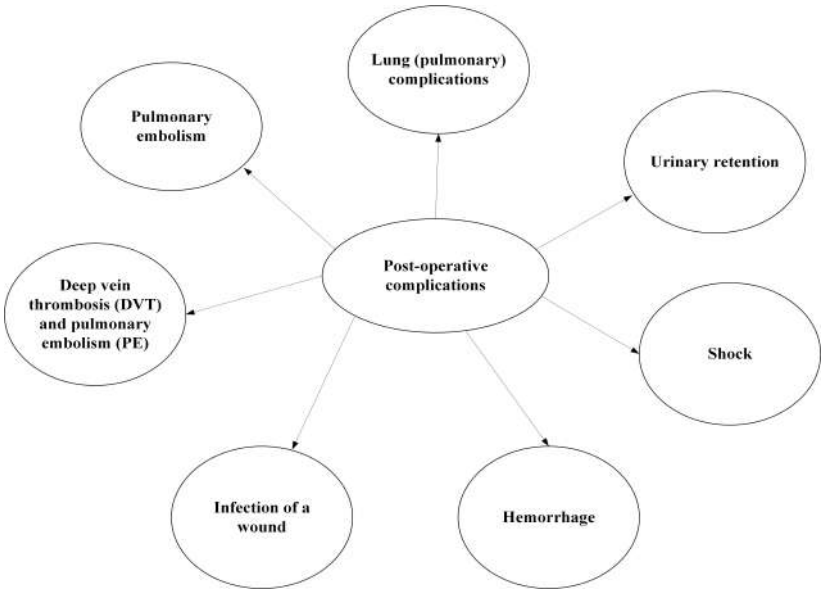

Figure 1: Post-surgery complications.

Compared to lifestyle treatments, including dietary changes, increased physical activity, and behavioral counseling for weight loss, bariatric surgery remains the best effective cure for extreme obesity and offers long-term weight control. Furthermore, bariatric surgery improves several obesity-related comorbidities, including type 2 Diabetes, dyslipidemia, hypertension, and sleep apnea. The sleeve gastrectomy has replaced the Roux-en-Y gastric bypass, the most communal bariatric technique accomplished worldwide. Only a few factors, such as youth, a lesser pre-operative Body Mass Index (BMI), male sex, and the absence of T2DM, have been associated with a greater rate of losing weight among people who have experienced bariatric surgery, even though a few research findings have already shown that there is a wide variation of losing weight among these patients.[17] However, advancements in surgical methods, localized micro-infiltration, and circulating tumor cells induce tumor growth after resection. Additionally, perioperative trauma-associated inflammation might hasten local development or tumor dissemination, which can encourage tumor recurrence. Following surgery, chemotherapy and radiotherapy are frequently used to stop the spread of local and metastatic tumors, although these treatments frequently have side effects. Furthermore, immunotherapy has been thought to successfully prevent the spread and recurrence of cancer.[8]

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With about 29.400 annual deaths as well as 165.000 people recognized with the disease across the United States in 2017, prostate cancer remains the most prevalent cancer among males. Radical prostatectomy remains one of the top treatments for prostate cancer patients since it has good long-term results.[13] Because it would only be given to individuals who were relapsing, radiation therapy (RT) has been frequently only given at the time of BCR, which would minimize treatment-related negative effects. Early salvage RT, according to some studies, is just as effective as aRT in this situation. The greatest predictor of recovery after salvage RT is recognized as a low pre-treatment serum concentration of prostate-specific antigen (PSA). However, it is still unclear if salvage RT at the initial instance of reappearance affects cancer control. Sometimes in patients with high-risk characteristics, the history of the science of relapse following radical prostatectomy (RP) is varied and may represent a variety of underlying tumour pathophysiological processes.[7]

The application of reflexology, although not acknowledged in the present medical diagnosis, including physiology, anatomy, and biophysics, is described in ancient techniques employing specific anatomical locations. These antiquated ideas are not used as the main diagnostic method in medicine. Because many diseases have a major impact on the electrical properties of specific bodily tissue, it is possible to diagnose many illnesses using those parameters. Today, several studies study tracking an individual's functional status (FS), influenced by several exogenous and endogenous elements. Various wearable gadgets, such as beepers that could save and investigate data about a specific patient's Functional Status, may be employed to evaluate a health state. However, they can provide important information about the health of organs. One form of artificial intelligence model used to solve various issues is neural networks (NN). To design concrete mix designs, researchers created NN to forecast dynamic concrete qualities.[33] The model predicts the physical parameters of concrete mix using the quantities of normal and special additions as input. A concrete mix behavior model was also created to forecast the ensuing compressive strength. This was contrasted with the significance vector machine, which offered high accuracy.[34] Online calculators are a significant breakthrough since they offer a quantitative assessment of the probability of recurrence at any stage following surgery. Tumor recurrence, on the other hand, is often categorized into either early or late relapse and is a significant postoperative complication.[2]

Neutrosophy is a subfield of philosophy that draws from the domains of logic, set theory, probability/statistics, and philosophy. An enhanced mathematical paradigm that works with ambiguous and unclear data is neutrosophic set theory. It was developed as a fuzzy system expansion.[4] Fuzzy classifiers handle varying degrees of accuracy in data that is unclear. The three functions the neutrosophic classifier defines are the false, true, and indeterminacy levels of uncertainty management.[35] These formulas need a ratio in the range of zero to one. Making the best decisions is facilitated by handling uncertain data utilizing neutrosophic techniques, which more accurately characterize the data and lower its unpredictability. Numerous disciplines utilize neutrosophic set theory, including physics, computer science, medicine, and mathematics. Neutrosophic set theory has substantial use in decision-making research. Its main benefit is the set's capacity to manage uncertainty and data incompletion. The neutrosophic set is crucial for noise reduction, clustering, segmenting, and categorizing actual data in numerous fields, including the medical industry. Fuzzy approaches and neutrosophic sets have created effective diagnosis systems that eliminate ambiguity and enable accurate diagnosis.[23]

A fuzzy neural network consists of grouping fuzzy logic and neural networks. Fuzzy neural networks associated with the aids of neural networks and fuzzy logic make knowledge representation simple and provide a powerful capacity for self-learning. This study presents the ideal access network as the output vector, with terminal side elements, network side elements, and based user elements as input vectors. This problem can be thought to be a multi-attribute decision-making issue. The complexity of the answers provided by this kind of intelligent model makes it difficult to convey them to individuals beyond the artificial intelligence fields. Fuzzy system principles have emerged to help smart models produce results more closely aligned with what is often expected. They enable us to add interpretability to the way the problems are represented. Designs combining the greatest features of both ideas to create hybrid representations, referred to as fuzzy neural networks and, otherwise, neuro-fuzzy models, have been projected to find a cogent synergy between neural network training capacity and the potential for trying to represent the troubles more understandably. Since the 1960s, these approaches have been discussed in the literature and used effectively and dynamically to address various issues in modern society.[9] Fuzzy structures and their hybrid origins have become increasingly effective at simulating common human thinking over the past few decades. The creation of structures with just a high degree of suppleness but also the self-sufficiency to develop their constructions and existing knowledge on developments in the environment, which are capable of handling modeling, control, forecasting, and categorization of structures in a scenario not static, vulnerable to changes made, is a significant area of existing research.[6]

The following sections comprise the remaining portions of this approach: The relevant works are presented in

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Section 2, along with a thorough analysis. Section 3 goes into much detail about that problem statement. Section 4 provides a detailed study of the suggested Fuzzy neural network modeling and current-voltage analysis for predicting post-surgery complications. In Chapter 5, the experiment's findings are presented, reviewed, and analyzed in-depth, along with a comparison to best practices. The sixth and final section concludes the article.

2 Related works

To monitor post-operative patients, the study creates a revolutionary IoT architecture that offers ultra-reliable low, latency connections. To provide the best performance for the targeted results, the work balances critical and non-critical patients. Additionally, a regression analysis utilizing machine learning is accomplished here on the sensory data of the patients to acquire extremely accurate forecasts of the patient having sensory data, which is patients' vitals, allowing perfect virtual investigators to anticipate the data in the event of a communication breakdown. The presentation evaluation of the suggested IoT-centred vital signs monitoring solution aimed at post-surgery patients offers reduced delay and packet loss. It is suggested that an IoT-enabled URLLC architecture be used to provide extremely dependable near-real-time transmission of the vital signs of the most important patients. It also guarantees priority access to critical patients and permits instantaneous channel admittance for critical and non-critical patients. The research also suggests using a gradient boosting-based regression technique that can forecast slowly changing patients' vital signs and rapidly changing ones. In the occasion of wireless communications failings, the procedure will continue to predict the patient's energy, raising alarms even when the wireless channel confronts recurrent intervention or unexpected variations leading to a communication failure. This algorithm acts as a supplementary layer of security for critical patients. Both slow and quick variable sensors for monitoring vital signs are also accurately predicted using the gradient-boosting regression approach. The study has several drawbacks. It will be fascinating to examine how the IoT-centred typically fits the actual patient checking whenever data is gathered in the clinical scenario because the sensory dataset for vital signs is generated synthetically[25]

Individuals are more worried about their health in industrialized societies. As a result, one of the most active research topics has been the advancement of medical sector application. According to medical data, cardiovascular disease is the leading cause of illness and mortality worldwide. The diagnosis of cardiac illness involves many variables, making the doctor's service challenging. Additionally, the facts and information a doctor gathers to make a diagnosis are sometimes incomplete and imprecise. The Internet of Things is currently being implemented in medical fields to offer fresh perspectives and other online resources. Numerous millions of individuals now have an additional means to access the frequent health advice they need to lead healthy lives due to these applications. In the research, researchers present an innovative structure based on IoT and computer-aided diagnostics to identify and track patients with heart failure, utilizing data gathered from many external sources. With unclear information, the suggested healthcare system tries to improve diagnostic precision. Researchers recommend the neutrosophic multi-criteria decision-making approach to help patients and doctors determine whether a patient has heart failure.

Additionally, users can determine the degree to which sickness is detrimental to their body by coping with the ambiguity of imperfection and vagueness caused by the symmetric priority scales of distinct illness symptoms. Numerical illustrations from actual case studies support the suggested paradigm. The experimental findings show that the suggested method offers a practical answer that can be applied across a broad spectrum, a new platform for millions of individuals to benefit from the reduction of mortality and expense of clinical care connected to heart failure. However, compared to the other techniques, the forecast accuracy is lower.[1]

An intracellular protein called selenium-bound protein 1 (SELENBP1) takes been found in the blood after myocardial infarction. Hypoxia and heart surgery impact the selenium (Se) level and selenoprotein expression. It was determined, for this purpose, to study the levels of SELENBP1 in the blood of patients whose heart surgery required cardioplegia and a cardiopulmonary bypass. Over the course of the entire surgical procedure, serum samples remained taken seven times. A recently created, very sensitive immunological test was used to measure SELENBP1. SELENBP1 levels in the serum rose exponentially even throughout the interference and significantly correlated with the length of ischemia. Serum attentions in SELENBP1 were substantially correlated with cardiac arrest as well as the length of myocardial ischemia as soon as throughout surgery, thereby creating a unique and prospective quantifiable marker for myocardial hypoxia. To define mingling SELENBP1

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more thoroughly as a biomarker of myocardial strain, their concentrations in patients who had an operation with cardioplegia-persuaded cardiac arrest and the utilization of cardiopulmonary bypass (CPB) being tracked and its possible diagnostic significance about recovery and existence was assessed. This marker can enhance diagnostics and forecasts when combined with the existing clinical criteria. This clinical investigation's small sample size is a disadvantage since it prevents thorough and stratified analysis of patient subgroups or sex-specific differences and restricts the outcomes to testing the main premise.[20]

The effectiveness of post-prostatectomy incontinence treatment using progressive resistance exercise of said pelvic floor muscle has been assessed in the study. 59 individuals who had undergone radical prostatectomy were assessed preoperatively in the prospective research. Following surgery, continence assessments were performed every 2 weeks, and an exercise program was started at 6 and 12 weeks. The continent condition was the primary endpoint, and the changes in muscular endurance and strength following the exercise intervention were the secondary result. The study included 59 patients in total. Six participants left the research due to noncompliance and orthopedic issues. In terms of prostate volume, age, body mass index, prostate-detailed antigen, pathological T stage, or pathological Gleason score sum, no statistically important variations were seen between the two groups of patients when the patients were alienated centered on their continence position.

The continental group also experienced considerably greater hip extensor endurance and muscle strength development over the 12-week exercise regimen and preoperative maximum urethral closure pressure. Only the decrease in hip extensor muscular strength was a significant factor in the multivariate analysis used to predict the attainment of continence status. Following radical prostatectomy, the improvement in hip extensor muscular assets in the present exercise program served as an independent prognostic of continence status. There are some limitations to the research. One reason is that it consisted of a prospective trial rather than a randomized controlled study. Additionally, just 10% of the earlier study group continued to participate, making the patient sample size extremely small. Finally, a single surgeon performed the radical prostatectomy using two surgical techniques.[29]

For the pediatric Pain Interference Scale as well as the Functional Disability Inventory FDI, 12 months following major pediatric surgery, the current study was created to prospectively evaluate pre-surgical youth but also parent risk factors. Due to the significant parental engagement in a child's surgical recovery, it had been expected that parental risk factors would predict functional limits in children one year after surgery. First, the FDI and PPIS are fundamentally different measurements and, as a result, are most likely to be influenced by several circumstances. Second, there can be consequences for the optimal course of action if there are variations in risk factors. In contrast, parent pain-related concerns would forecast pain-associated functional limitations, according to our hypothesis. Parent general anxiety would forecast general functional restrictions.

Additionally, it was expected that youth pain-associated anxiousness would be related to pain-related functional limits and that youth general anxiousness would be associated with generalized functional limits. Peripherally, the study sought to investigate the relationship between functional limits and the presence of chronic pain. There are numerous restrictions to be aware of. First off, the sample was tiny, which restricted any possible generalization. Replication in a bigger sample is therefore necessary.

Additionally, more complex statistical methods, including structural equation demonstrating, were not available to investigate the indirect connections between anxiety sensitivity, parent anxiety, and results of child pain interference. Second, because this is a subsequent study, there are two possible problems: first, there may be a high possibility of errors because no prior sample size computations were made for this result. Third, it's likely that these secondary assessments' potential confounding variables weren't measured.[31]

According to medical data, cardiovascular disease constitutes one of the leading causes of death in the general population. Individuals in countries with greater poverty are less concerned with their health. The risk is rising as 550 fatalities per hundred thousand individuals occur annually in Egypt.[15] Medical professionals still struggle to precisely determine heart disease because there are so many factors to consider. In addition, data obtained for diagnosis are frequently imprecise and unclear. The study's primary contribution is formulating a unique neutrosophic set-based theory for cardiovascular patient risk categorization. To validate the suggested model, it is applied to the most important characteristics of the chosen dataset and contrasted with other well-known classification methods. According to the experimental findings, the suggested model for classifying cardiac diseases has the greatest accuracy and F-measure values. However, the absence of an individual error results in an inaccurate definition of the membership function.

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A thorough lipid metabolomics evaluation of serum utilizing high-resolution exact mass spectrometry since the two case-control pieces of training that also comprised non-Breast Cancer, Breast Cancer disciplines before surgery, and Breast Cancer topics one month after surgery to define whether the metabolic signatures of well-over fatty acid deformation as well as other lipid modifications could be used to overcome these issues of radiation acquaintance, inconvenience, and reliance on the level of ability of operators was accomplished. The proportions of linoleic acid towards oleic acid assessed in several lipid pools decreased before breast cancer participants. However, these ratios enlarged after surgery and weren't lengthier distinct from non-Breast Cancer individuals. The ethanolamine plasmalogen species, including docosahexaenoic acid, were shown to be further lowered in Breast Cancer participants one month after surgery compared to pre-surgery levels, with a p-value of 0.001. This contrasts with the extension biomarkers.

These findings support the idea that ELOVL5 is overexpressed in Breast Cancer tissue, which would also lead to a selective depletion of lipid species comprising 18:2 as opposed to 18:1 molecules. Surgical excision of the tumor eliminates the hyperactive ELOVL5 impact on serum lipids. The low EtnPls levels, on either hand, might be pre-existing and a potential risk aspect for Breast Cancer because they do not seem to be brought on by Breast Cancer tumor activity. These findings suggest that a straightforward blood test can potentially check for both breast cancer risks and cancer activity. Additionally, the study contains some flaws. One month after surgery, a follow-up is conducted. Lengthy post-surgery follow-up is required to show whether EtnPls and lyso-PtdCho levels alter. The transferability of the results may also be constrained by the fact that there were just Japanese respondents and a limited number of them overall.[37]

The study has created a new dimension tool, the identity protection of orthopedic post-surgery inpatients measure, which can give medical professionals a deeper understanding of orthopedic patients' self-perceived safety and offer more precise clinical recommendations. The six-factor model was shown to have a good fit using item analysis and exploratory factor analysis (EFA), as measured by the incremental fit index, goodness-of-fit index, comparative fit index, root mean squared error approximation, and root mean square residual (RMR). The findings demonstrated that the orthopedic post-surgery inpatients' perception of their safety scale is a reliable and relevant tool for assessing the perceived safety of orthopedic post-surgery patients. There are several restrictions to the study. The characteristic sampling restriction is the initial restriction. Only orthopedic patients who were approximately old were taken part in the study. Although appropriate data collecting and statistical techniques were employed throughout the investigation, another drawback is the relatively small sample sizes.[39]

In respectable non-small cell lung cancer, the predictive significance of mingling tumor cells and gene and miRNA tissue activity was examined. In contrast to squamous cell cancer (SCC), the relationship between CTC subpopulations and the fate of patients with excised early phases lung adenocarcinoma (ADC) was examined at three separate time intervals (CTC1-3) (prior surgery, over one month, and then afterward six months). Epithelial-to-mesenchymal transition (EMT) markers, immunological profile, and tissue expression of genes and microRNAs were also linked with the result. Various CTC subpopulations were present due to the various tissue expression profiles indicated by the ADC and SCC. MiR-155 in ADC is also associated with the expression of AXL and IL6R, which was connected to EMT CTC1. In the multivariate model, CTC2 and CTC3, and AXL were independently predictive factors for relapse-free survival and overall survival, respectively, exclusively in ADC. Those patients' prognoses were unaffected by either the surgery or adjuvant therapy. The study explains how tissue AXL appearance and the existence of CTCs following operation affect patients with adenocarcinoma prognosis. Potential indicators for said stratification of ADC individuals who may benefit from novel adjuvant therapy include tissue AXL appearance and CTC EMT activation. Despite the homogeneity of histological subtype groups, the results are restricted by the small number of individuals considered. The manual approaches used to determine the existence of CTCs could potentially have intrinsic methodological flaws. Thus, strict, standardized test procedures have been used here to reduce bias and technical variances, and the results were graded by two qualified clinical pathologists.[10]

3 Problem statement

This clinical investigation's extremely small sample size is a drawback because it prohibits extensive and stratified study of patient subgroups or sex-specific variations. It also limits the results to verify the central hypothesis. One reason is that it was a planned trial instead of a randomized controlled study. The patient

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Table 1: Types of post-surgery patients.

Type 1	Low-risk group
Type 2	Postoperative issues of several kinds
Type 3	Required more therapy

sample size was incredibly limited due to the minimal number of participants from the initial trial group. The results are constrained by the small number of people considered despite the uniformity of histological subtype groups. The manual techniques utilized to find CTCs may have inherent methodological problems. Participants in the current study were elderly patients. Although proper data collection and statistical methods were used throughout the inquiry, the comparatively small sample sizes are still problematic. Neutrosophic Fuzzy neural network modeling and current-voltage analysis for predicting post-surgery hazards were used to overcome these issues.

4 Materials and methods

Age is a factor in the prevalence of benign prostatic hyperplasia, termed BPH.[38] The sickness and its aftereffects frequently result in a significantly reduced quality of life, even when the condition is not life-threatening. Even though it's not considered a reason for surgery right away, acute urinary retention needs serious care, which frequently includes surgery. These procedures are carried out in four urology facilities. The information was gathered over twelve months on behalf of a department monitoring project.

Predicting the likelihood of problems after BPH surgery was seen as a diagnostic challenge. 55 patients of the 100 who received prostate surgery were in the low-risk group (type T1), 25 patients experienced a variety of postoperative problems (type T2), and 20 patients needed extra therapy (type T3). The patients under observation had extensive clinical and laboratory tests before surgery. Then, descriptions for every patient were created.[12] Table 1 represents 3 types of people.

4.1 Current-voltage characteristic model

The application of a normalization strategy based on the regulation of biologically active points (BAP) characteristic energetic dynamics during periodic regulated BAP exposures to an external factor Studying the current-voltage characteristic of such electrical conductivity of biologically active points and generating characteristic points those positions could be utilized to produce descriptors aimed at categorizing representations are two methods for analyzing the diagnostic assessment of said electrical conductivity of biologically active points. A design of such a BAP current-voltage characteristic is necessary to identify these distinguishing spots. The BAP current-voltage characteristic was created using bipolar current pulses with amplitudes ranging from zero to the maximum value dictated by pain and heat thresholds.

A current-voltage characteristic design was created using the heuristic approach, which relies on expert knowledge (assumptions) about how the object under research operates, or the phenomenological design, which bases it on a mathematical and perhaps homeostatic model of explanation of the obtained experimental data. As a result, it is necessary to form two distinct kinds of parametric methods wherein descriptors are employed as independent variables. Data collected through experimental analysis defining the features of the biomaterial beneath specific conditions is utilized as a dependent variable. An effective model construction will greatly ease the task of building a classifying model because the setting of the data generated because of investigational research is determined by a very small number of components, known as dormant variables. The general representation of the current-voltage characteristic design is exposed in Figure 2.

The mismatch among the first and second-pass characteristics is a distinctive aspect of the BAP current-voltage characteristic. Furthermore, irrespective of if the first permit starts through +U_{max} or along -U_{max}, the second pass's characteristic consistently sits over the first pass's characteristic. When the contact to bipolar current

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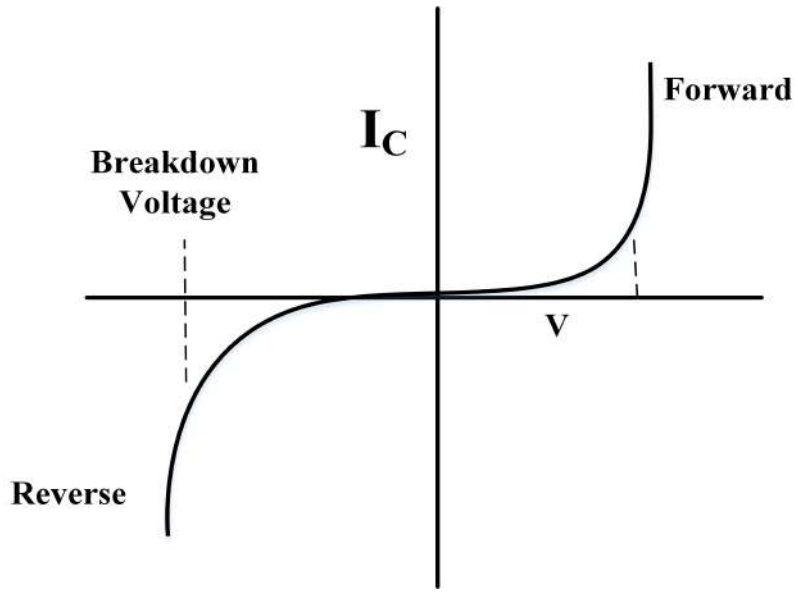

Figure 2: The general representation of the current-voltage characteristic design.

pulsations is thought of in terms of dynamics, it remains feasible to see the current-voltage characteristics rotating counterclockwise, which describes their trajectory nearing the ordinate axis.

The voltage shift in the biomaterial between - Umax to and +Umax (the first pass) correlates to the green division of such current-voltage characteristic, and the voltage modification from + Umax to - Umax (the second pass) belongs to such a red branch. As a result, a two-pass characteristic is used to describe this current-voltage characteristic. A continuum of rescindable BAP CVCs is obtained to define the descriptors used to categorize a person's functional condition. Descriptors comprise pairings of vectors, where every other pair of vectors correlates to an informative abscissa. Empirical selection is used to determine the quantity and location of informative abscesses.

The points of the Current-voltage characteristic typical that make up the area of the relevant feature are as follows: a_k are the directions of the abscissa axis of the ascending as well as descendent branches of the CVC that correlate to the ordinate I_2, and bl are the directions of the ascending as well as descendent branches of the CVC that correlate to the ordinate I_2.

The initial vector correlates directly to points of the juncture of such abscissa with ascending branches of said current-voltage characteristics and the second one with descendent branches of said current-voltage features. The elements of the vectors correlate to the points of CVCs lying here on informative abscissa in this manner. The following definitions in equations (1) and (2) describe the elements of the vector:

$$\Delta R_k = \left(\frac{(R_{k+1} - R_k)}{R_k} \right) .100 \tag{1}$$

$$\Delta R_l = \left(\frac{(R_{l+1} - R_l)}{R_l} \right) .100 \tag{2}$$

where k=0. . . ., n, l=0..., n, is the numeral of digitized points just on CVC, and R_k is the confrontation of the positive aspect of CVC's ascending and descendent branches correlating to ordinate I_1. R_l is the resistance of the positive portion of the ascending and descending branches of CVC conforming to the ordinate I_2. The BAP was used to measure the volt-ampere characteristics using voltage steps of 1 V between -15 V and +15 V.

Assume that the resistance exceeds the chosen threshold for any points from the array Diagnostic Points D_P again for the class. In that situation, it is determined if the sureness in the hypothesis omega sub i. is equivalent to 0 or the accuracy of the generated forecast model in the prognosis ω_i. The equation expresses this,

$$(Y_l \in [D_P]_l : \delta R_l \geq \delta R_l,\ thershold) \tag{3}$$

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Y_l represents the BAP identification names from a list of instructive points in this equation. The nominal significance of the Active Point's confrontation with the index is the threshold significance that designates the array of normal values. Excess of the value d R_l denotes the fulfillment of the hypothesis for the class of conditions being analyzed.

4.2 Fuzzy neural network

Fuzzy neural networks (FNN) combine learning, recognition, association, and information processing with the benefits of neural networks and fuzzy theory. The straightforward properties of items in the transition phase are ambiguous, and the fuzzy hypothesis makes their species unclear. Random and vocabulary uncertainty comprises the two basic categories of fuzzy logic uncertainty. Generally, random uncertainty describes the likelihood that events will occur randomly. Fuzzy logic's biggest benefit is enabling users to express expected system behavior using a straightforward if-then relationship.

Utilizing FNN to risk assessment systems has three benefits: initially, it has a robust parallel processing methodology, strong adaptability as well as reasoning capabilities, and a great ability to handle fuzzy information, making it ideal for patient risk evaluation when information exchange is inadequate as well as the rating process is not thorough; second, it includes a robust capacity to learn in a changing environment. Third, FNN is a natural nonlinear modeling procedure that could successfully overcome the challenge of choosing suitable design functions in traditional modeling and investigation processes, allowing for quick model construction. It could find rules from a large amount of data and therefore should generate comparatively correct reasoning, which would suit the circumstances of limited information on patients' will. With such benefits as great applicability and practicability, FNN seems to be a multi-layer feed-forward network simulation model computer structure that has the ability of learner autonomy.[11,18,40]

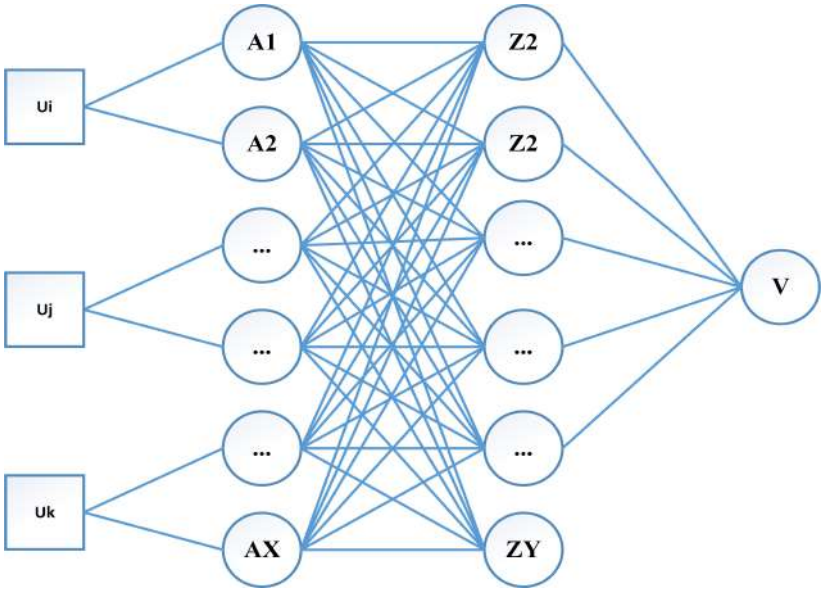

Figure 3: Fuzzy neural network architecture.

Figure 3 shows a fuzzy neural network structure. The fuzzy neural network syndicates the benefits of neural networks and fuzzy theory. It can do more than just finish processing ambiguous data. The neural network structure could be employed to accomplish the model's learning and adaption even with the attributes' ambiguity. Fuzzy neurons make up each fundamental component of said fuzzy neural network. The following categories of fuzzy neurons are listed as the fundamental ones. The fuzzy neuron's job is to transform the output value from the level determined into a fuzzy one.[3,16,24,27]

$$zt = Gt\theta t + ut, ut \sim N\left[0.Ut\right] \tag{4}$$

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Fuzzy neurons output specific signals that they have converted from fuzzy values. Formally comparable to earlier neurons, this camphor-glided cell type seems to have the opposite effect.

$$\theta t = \theta t - 1 + vr, vr \sim N\left[0, Vt\right] \tag{5}$$

The neural network learning method must choose the network's parameters according to the information because various samples have varied data ranges. Because of the variations in these data, it will be challenging to establish the neural network's parameters and guarantee correctness.

$$(\theta 0 \mid E0) \sim N\left[m0, B0\right] \tag{6}$$

To address the issue, this study normalizes all the fuzzy adaptive information to the range. The normalization process is described by.

$$Et = \{zt, Gt, Et - 1\} \tag{7}$$

$$(\theta t \mid Et - 1) \sim N\left[bt, Qt\right] \tag{8}$$

Contrarily, despite its significant advantages, people lack clarity on the theory behind the adaptive neural network modification.

$$(ZT, Et - 1) \sim N\left[gt, Rt\right] \tag{9}$$

The RBF neural network serves as the foundation for the fuzzy neural network's structure, which is extended to include no more than three layers and a connection weight decided by the input function rather than being predetermined.

$$Y = 0, 1 \; and \; Y * y \left|2W\right.(y) - b - z] - W\left(y\right)y = 0 \tag{10}$$

$$F\left(y\right) = \left[2W\left(z\right) - b - z\right] - W(y) \tag{11}$$

The primary purpose of every node in the layer, which corresponds to a fuzzy rule from the fuzzy rule collection, is to act as the antecedent of matched fuzzy rules before solving the fitness of the associated rules. This nomination of every fuzzy neural node is primarily how the ignition intensity problem is solved. Every node in this layer represents its input and output.

$$\left\{ \begin{array}{c} Max\; F\left(y\right) = 2W\left(0\right) - b - Z \\ Min\; F\left(y\right) = W\left(1\right) - b - z \end{array} \right\} \tag{12}$$

$$\left[2W\left(y-\right) - b - z\right] - W\left(y-\right)y- = 0 \tag{13}$$

The conjugate gradient technique sets the initial search direction as negative. The second and following search orientations are conjugated with the initial search direction. To find the best learning rate, conduct a linear search all along the new search direction. This approach typically converges faster than the common neural network methodology.[19,21,32]

A neutrosophic set exists between [0, 1]*, the irregular unit interval, where each member of its contents has a degree of truth, indeterminacy, and falsehood, respectively. The uncertainty present, or the indeterminacy factor, is independent of the truth and falsity values, in contrast to intuitionistic fuzzy sets where the integrated uncertainty relies on the degree of non-belongingness and belongingness.[5,26,28] Since there are no restrictions on the degree of indeterminacy, degree of truth, or degree of falsehood, neutrosophic sets are more generic than IFS. Each grade is independently variable between [0, 1]*.

$$C = \{\langle x, H_C(x), J_C(x), D_C(x)\rangle \left|x \in X\right.\} \tag{14}$$

Let X be a space of points, and let *x* be a generic element inside X. A truth membership function,$H_C\left(x\right)$, an indeterminacy memberships function, $J_C(x)$, and a falsity memberships function, $D_C(x)$ define a neutrosophic sets C in X. Here, the real subgroups of [0, 1] are$H_C\left(x\right), J_C\left(x\right),$ and $D_C(x)$.

$$\left[2W\left(y-\right) - C - z\right] - W\left(y-\right)y- = 0 \tag{15}$$

Equation 15 gives the combined equation of the neutrosophic fuzzy neural network. It is important for predicting post-operative risk since the model may need to consider different sources of ambiguity and uncertainty. Figure 4 explains the proposed methodology.

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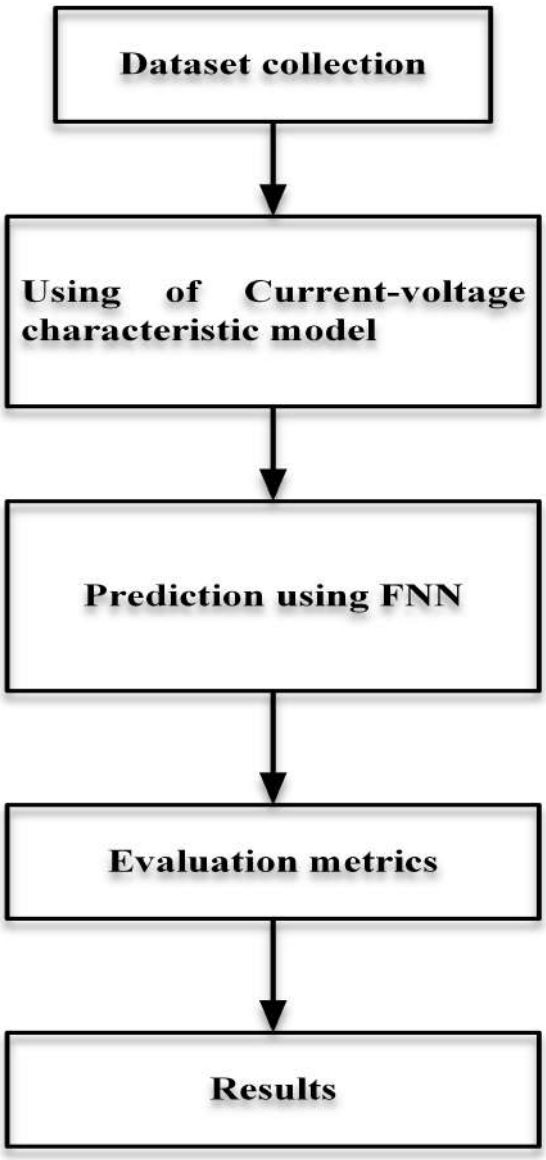

Figure 4: Proposed methodology for predicting post-surgery risks.

5 Results and discussions

5.1 Performance evaluation

The following formulas were used to compare the effectiveness of the proposed system to that of the existing systems to analyze and show its superiority. Equations that define the accuracy's sensitivity, precision, and specificity are among those that quantify it.

1. **Accuracy**

Accuracy assesses how precisely the system model functions. It is typically the ratio of accurate outcome expectations to all data. Equation speaks with accuracy (16),

$$Accuracy = \frac{T_P + T_N}{T_P + T_N + F_P + F_N} \tag{16}$$

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Table 2: Performance evaluation based on NFNN.

	Accuracy (%)	
	Training	**Testing**
NFNN (Proposed)	95.95	95.90

1. **Precision**

The number of accurate positive estimates disregarded by the total positive estimations is used to estimate precision. The percentage of accurately diagnosing cancer in the afflicted area is determined using Eqn (17),

$$P = \frac{T_P}{T_P + F_P} \tag{17}$$

1. **Sensitivity**

The sensitivity is defined as the entirety of all true positives and false negatives divided by the precision of properly forecasting positive outcomes. It shows what percentage of the values predicted by equation (18) was accurate.

$$R = \frac{T_P}{T_P + F_N} \tag{18}$$

1. **Specificity**

Equation (19) expresses specificity, where TN stands for true negatives. These negative instances appear negative and are classified as negative, or even FP for false positives, described as negative cases incorrectly labeled as positive. This suggests that specificity complies with the restricted likelihood of true negatives if a second class is present, which also means that this accounts for the probability of the presence of the negative terminal.

$$Specificity = \frac{T_N}{T_N + F_P} \tag{19}$$

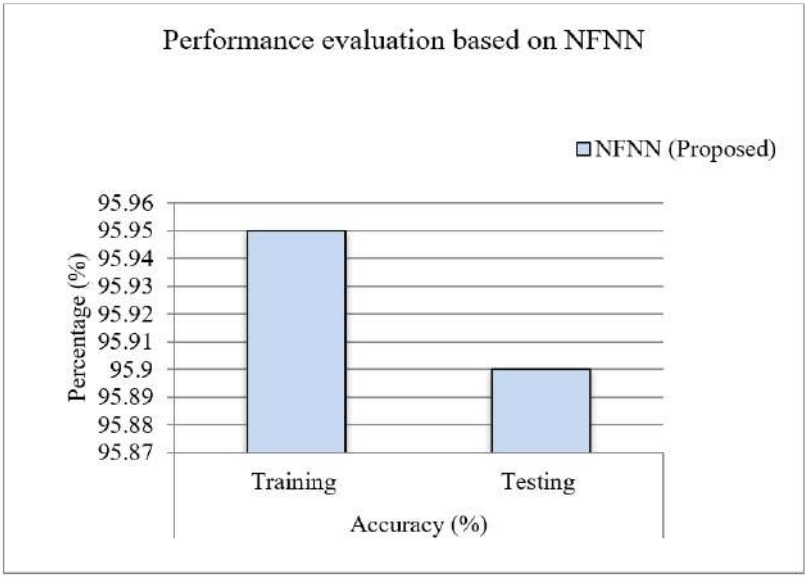

Figure 5: Performance evaluation based on NFNN.

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Table 3: Accuracy, precision, Specificity, and Sensitivity values of the proposed method.

	NFNN (Proposed)
Accuracy (%)	95.95
Precision (%)	95.34
Sensitivity (%)	95.87
Specificity (%)	95.91

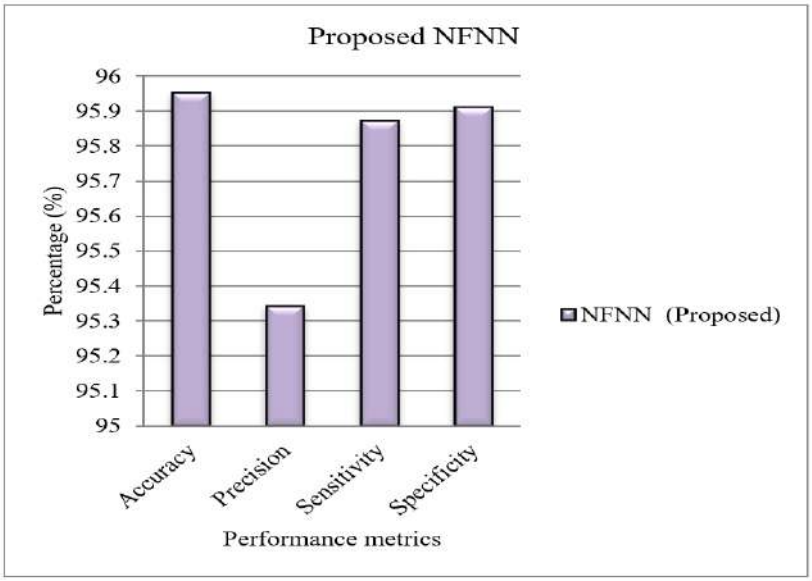

Figure 6: Accuracy, precision, Specificity, and Sensitivity values of the proposed method.

The performance assessment of NFNN-based training and the testing accuracy is presented in Table 2. Figure 5 displays the performance assessment of training and testing accuracy based on NFNN. Our study uses current-voltage analysis and neutrosophic fuzzy neural network modeling to predict post-surgery risks for patients with an accuracy of 95.95% during training and 95.90% during testing.

The values for the precision, accuracy, specificity, and sensitivity of the suggested technique are shown in Table 3. The proposed method's performance estimation is shown in Figure 6. In our study, post-surgery risks for patients were estimated using current-voltage analysis and neutrosophic fuzzy neural network modeling, with 95.95% accuracy, 95.34% precision, 95.87% sensitivity, and 95.91% specificity as the results.

Table 4 compares the recommended and other current techniques' accuracy values. Figure 7 also compares the accuracy figures for the proposed method and other currently used methods. Our study combines current-voltage analysis and neutrosophic fuzzy neural network modeling to forecast post-surgery hazards for patients with a 95.95% accuracy rate. Our neutrosophic fuzzy neural network modeling and current-voltage analysis are more accurate than earlier machine learning-based methods.

Its usage as a helpful tool to assist clinicians in the initial identification and specialized cure of disease is validated by the NFNN model's exceptional accuracy in forecasting the risks associated with surgery following surgery. The research demonstrates that it is possible to predict the development of diseases and variations in

Table 4: Accuracy values of proposed and another existing method.

	Accuracy (%)
NFNN (Proposed)	95.95
Machine learning	94.4

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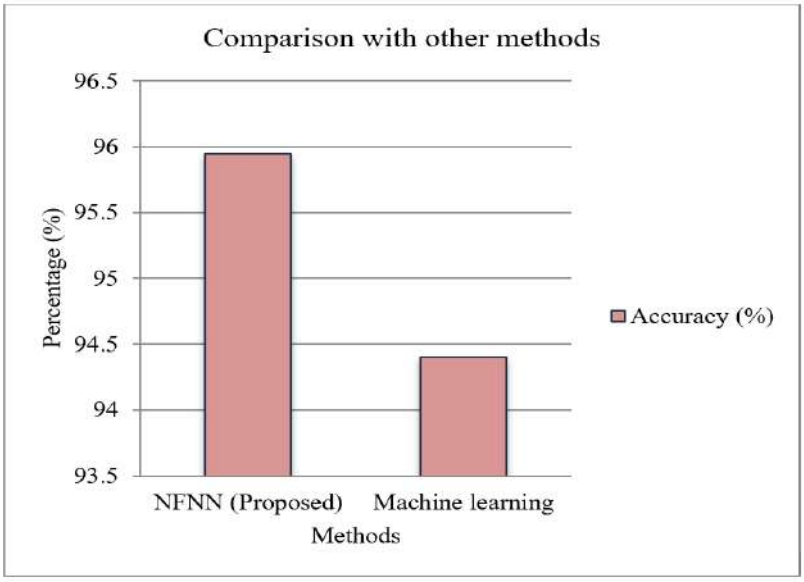

Figure 7: Accuracy values of proposed and another existing method.

functional states by analyzing the electrical resistance of physiologically active areas. This is because physiologically active points and the various levels' meridian structures exhibit abnormal organ performance before the disease's clinical symptoms. The NFNN model's excellent accuracy in predicting the risks associated with surgery after surgery validates its usage as a useful implement to aid doctors in the quick diagnosis and specialized treatment of disease. The model will eventually be integrated into systems for monitoring biologically active points and beeper operations.

6 Conclusion

The provided technological and algorithmic methods can be advised for application in diagnosing disorders due to the diagnostic capabilities of said efficient system. The model showed great promise as a specialized system. In several instances, the model just needed a few rules for an amazing result. With a 95.95% accuracy rate, the study combines current-voltage measurement and fuzzy neural network modeling to forecast patient post-surgery risks. The neutrosophic fuzzy neural network model incorporates the concept of neutrosophy, which deals with analyzing indeterminate and uncertain information. This may be relevant in post-surgery risk forecasting, as various sources of uncertainty and ambiguity must be accounted for in the model. The neutrosophic fuzzy neural network model's high level of accuracy in predicting the risks associated with surgery after surgery validates its usage as a valuable implement to aid doctors in the early detection and specialized cure of disease. The study shows that by examining the electrical resistance of physiologically active regions, it is feasible to forecast the progression of diseases and changes in functional states. This is because, even before a sickness manifests its clinical symptoms, physiologically active sites and the structures of different levels of meridians show faulty organ performance. Its usage as a helpful tool to assist clinicians in the early identification and specialized treatment of disease is validated by the NFNN model's exceptional accuracy in forecasting the risks associated with surgery following surgery. The model will eventually be incorporated into beeper operations and biologically active point monitoring systems.

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