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Fault Detection in IEEE 33kV Distribution and Micro-Grid Networks using Random Forest algorithm with NN Approach

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Abstract - An intelligent method using RFO approach is suggested in this study for identifying defects. In order to shorten outage times and increase service reliability, operators must quickly identify the problem segments. Uses circuit breakers and transfers to identify critical device areas, Stealthy for the sound sub-gadget, and Island for the inability islands, based on the problem popularity of circuit breakers and transfers. At this point, enrollment is calculated for each possible fault stage. The best willpower approach dictates the most attainable lack area. IEEE 33kV circulation system and Micro-Grid networks are used as case studies for the approach.

Keywords: Fault detection, RFO-NN approach, membership function & micro grid network

1. Introduction

When a fault arises, power appropriation has a significant impact on the management rebuilding fee and customer loyalty, making it a major problem for the electric power business. In order to shorten the time it takes for a power outage to occur and to increase administration reliability, administrators must quickly identify and fix any areas of weakness. It is possible to find the root of a problem by using something called "deficiency segment place," which uses circuit breakers and other safety devices to identify problems on a smaller size lattice. It is possible to reduce the cost of reclamation by pinpointing specific issue spots and their root causes. After a flaw is discovered, it seems to be impossible to restore management. There are now SCADA systems in use for the powerful pastime of intensity transmission and small-scale matrix architectures in complex electrical frameworks nowadays. False alarms may be generated in SCADA systems due to the defective or malfunctioning of the system's transfers and circuit breakers in the post-trouble state. When a breaker fails to operate, the problem is remedied by using back-up breakers to restore power. When the blackout range is large, it's difficult for dispatchers to avoid making a snap decision about where the problem may be discovered. In any event, the parameters for hand-off time in power transmission frameworks are much smaller. As a result, challenging scenarios may arise if the time delays are not entered with sufficient accuracy, and melancholy might have real consequences. Additionally, numerous flaws might appear from time to time, with multiple breakers being discovered in a short period of time. Because of the sheer volume of warnings, dispatchers are unable to see the situation positively [3].

Researchers in this research have developed a method to help directors identify and correct deficiencies in their organisations. The database may be stored with much less RAM (miniaturized scale lattice topology and the submit deficiency reputation of circuit breakers and protecting transfers). Sisland, for the absence of islands and circuit breakers and transfers with a reputation for post-failure failures, is an important machine area in this architecture. Afterward, it generates participation artwork for each conceivable spot where a lack exists. With the results of this calculation, we may estimate the likelihood that each application will be admitted to the deficiency section. Enrollment also provides valuable tools for identifying and prioritising potential (or candidate) weaknesses, and they are the most important variables in basic management. The most practical problem area is treated with the most willpower approach during basic management. The single phase in which participation has grown the most in this strategy is the one with the greatest tolerable deficit [1]. Algorithms for IEEE 33kV distribution systems (four) and microgrid networks (four) are implemented in MATLAB software, and they are tested in eight case studies.

The five parts of this broadsheet are laid out as follows: Microgrid networks and distribution systems are briefly discussed in Section II. The RFO-NN sets are discussed in Section III. Section IV explains the technique and approach for detecting faults. Results and discussion are presented in Section V.

2. 33kv IEEE Distribution System & Micro-Grid Network

Describes two test systems that were used as case studies in this research.

2.1 Test system 1: IEEE 33kV Distribution System

Figure 1 depicts a prototype testing system. How many delivery bars (1-B12), line segments (1-L8), and transformers (1-T8) comprise an IEEE 33kV distribution framework? There are 28 factors in total on this framework for each of the segments. A total of 84 defensive transfers and 40 circuit breakers (CB1-CB40) are used to protect these components, with each electrical transfer providing necessary, non-obligatory, and tertiary warranty zones for each component. Circuit breakers repute is only changed by the assessing transfers when the 40 circuit breakers are open or closed under normal operating conditions.

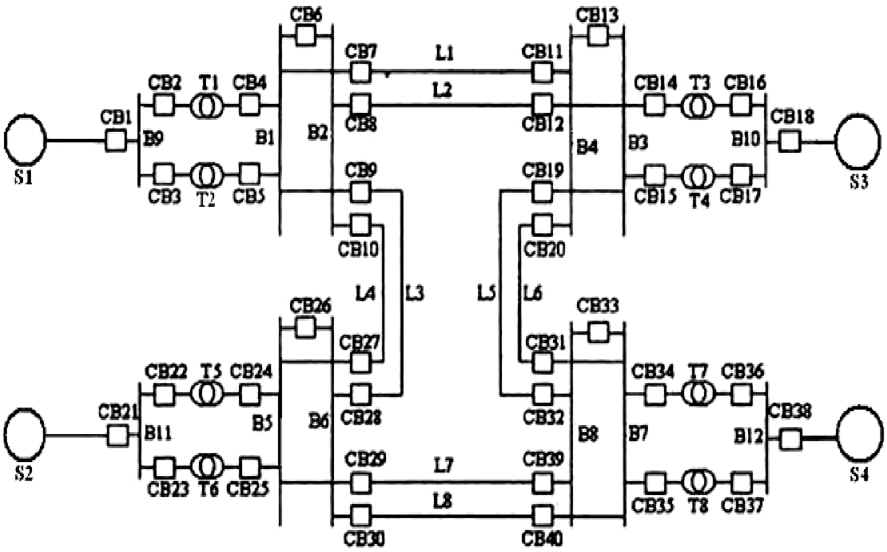

Figure. 1. IEEE 33kV distribution system

2.2 Test system 2: Micro-Grid Network

At the same time as providing continuous power supply to extraordinary masses and cease-clients, the tiny scale framework functions as a phase in the electricity framework that contains at least one DG gadget. Figure 2 depicts the micro-grid network.

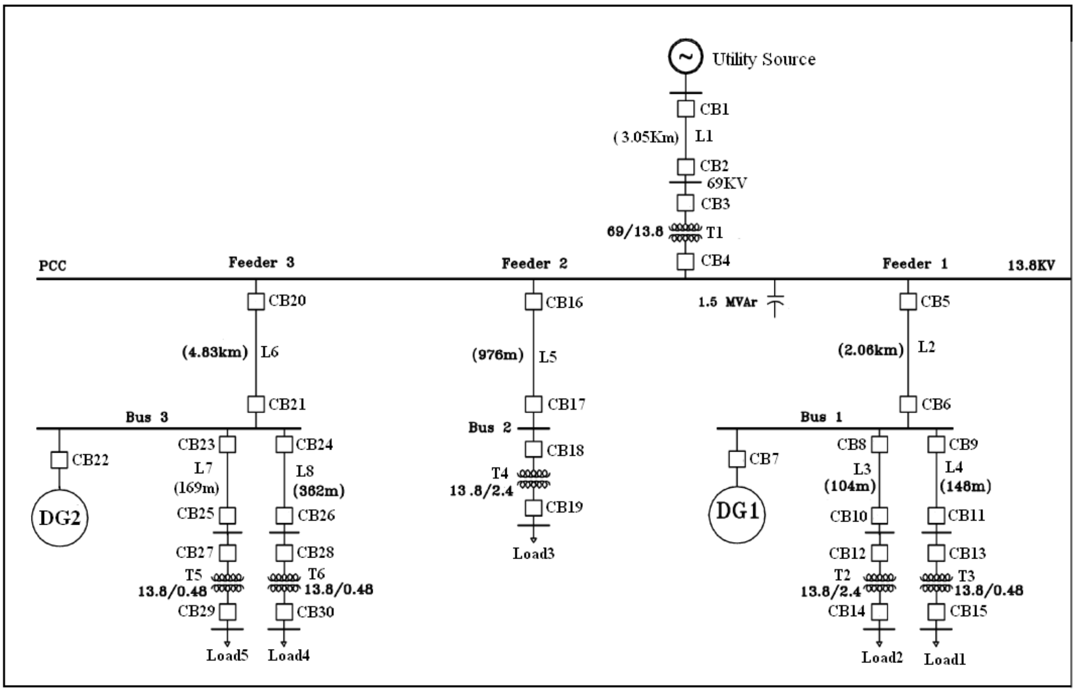

Figure. 2. Representation of Micro Grid Network

3. Concept of RFO-NN Sets

When a new set ascends or descends at the same time, it causes its additives to become completely disconnected from one another throughout the cosmos. There is no such thing as an exacting order as far as the human mind is concerned. When seeing a physical movement, we strive to "version" it by paying attention to it in various ways. Such a displaying technique is an essential denominator for exam, structure, reproduction or utilization of the event. While demonstrating it, the version may be a fundamental articulation, a parent, a square graph, and so on and the parameters of the model can never be freshly specified. Consider the average monthly wage at a software business as an example. Consider the following while discussing salary:

Mr. X gets HIGH SALARY.

Consider that a salary of Rs.25,000/- or more is considered HIGH SALARY if we attempt to utilise a crisp set to differentiate between HIGH and NON-HIGH salaries. Anyone who earns Rs.24,500/- does not get a high salary. But common sense does not allow for such a dichotomy to be made Because there is no line between Rs.25, 000 and Rs.24,500, the idea of a "crisp set" runs afoul of this reality. In Fig. 3, we depict our definition of high salary as a continuous, variable surface.

According to our definition of high salary, Rs.40, 000/- is a reasonable figure, while Rs.7,000/- is a complete fabrication, since it doesn't even come close. True material regarding our notion, High Salary, increases as we go along the X-axis. As a result, it is clear that the curve labelled "HIGH SALARY" is perfectly in sync with our thought process. RFO-NN sets, generally known as membership functions, are used to describe physical variables as continuous curves.

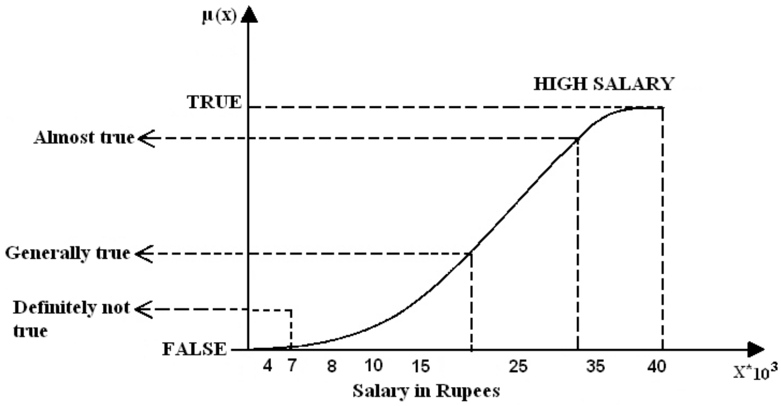

Figure. 3. The concept of RFO-NN set

The fluffy reason is a human-induction organised AI technique that has gained increasing attention from the construction sector throughout the globe.. The weakness of human core leadership may be rationalised into a fluffy cause-centered framework. An enrollment work will be used to collect the estimated and subjective limit states of framework factors. In the case of semantic needs, for example, a fluffy framework implements works in near-human terms, with thinking through fluffy motivation, which is itself a full clinical management.

Consolidating and converting fluffy units have precisely defined duties, much as regular units. It is because of these theoretical capabilities that a powerful equipment of reason is provided. Aside from the signature artwork, the activities, affiliation, crossroads, and supplement are all described just as they are for old-fashioned sets. Figures 4 and 5 depicted two fluffy sets An and B, with participation capacity A(x) and B(y). Consolidating these fluffy sets may be done in a variety of ways, as seen below:

- Intersection $\mu_A(x) \cap \mu_B(y) = \min\{\mu_A(x), \mu_B(y)\}$
- Union $\mu_A(x) \cup \mu_B(y) = \max\{\mu_A(x), \mu_B(y)\}$
- Complement $\sim \mu_A(x) = 1 - \mu_A(x)$

Subsequently RFO-NN sets remain not crisply segregated in the similar way as Boolean sets, these procedures remain applied at the truth membership equal.

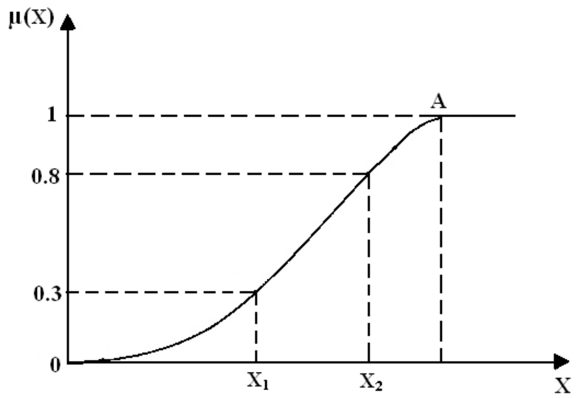

Figure. 4. Display of Set A's RFO-NN Parameters

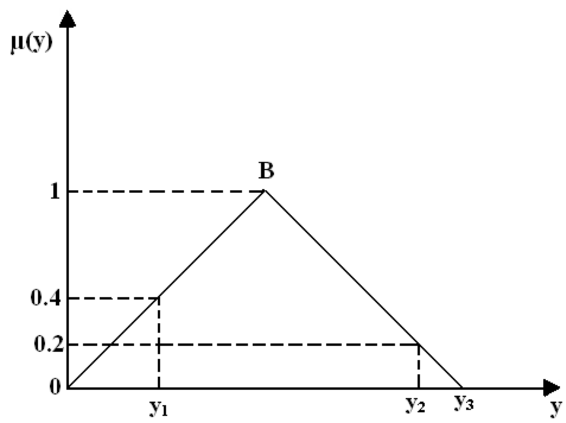

Figure. 5. RFO-NN depiction of Set B.

As with the logical OR operation, combining two sets is done by attracting the largest number of the truth membership values. The union of the two RFO-NN sets A and B is

$$\mu_A(x=x_1) \cup \mu_B(y=y_1) = \max\{\mu_A(x_1), \mu_B(y_1)\}$$

$$= \max\{0.3, 0.4\} = 0.4$$

$$\mu_A(x=x_2) \cup \mu_B(y=y_3) = \max\{\mu_A(x_2), \mu_B(y_3)\}$$

$$= \max\{0.8, 0\} = 0.8$$

4. Algorithms and Methods for Finding Faults

In the event of a malfunction, the fluff GA master framework is activated immediately after the main electrical switch is opened, causing an uncomfortable sensation. the shortcoming idea fi pursues at that point:

$$F_i = Fi\,(CB) \cup F_i\,(RL) \quad (1)$$

$$= \{C_i, U\,(C_i)\,|C_i\, \varepsilon\, S_{island}\}$$

$$P_{fault} = \{F_i\} \quad (2)$$

$$F_i\,(CB) = \{C_i, Ucb\,(C_i)\} \quad (3)$$

$$F_i\,(RL) = \{C_i, Url\,(C_i)\} \quad (4)$$

Where Ci is single of the probable mistake segments.

Pfault is the RFO-NN set that includes all possible fault regions and their involvement capabilities.

Fi (CB) is a RFO-NN subset that only includes circuit breakers that have tripped.

Fi (RL) is the ambiguous subset that only includes the laborious transfers.

U(Ci) is a section of Ci dedicated to participating artworks. In Ci's enrollment work, Ucb (Ci), Ci has a place among the fluffy set by focusing just on the fumbled circuit breakers.

Url (Ci) is an example of Ci's participation art that focuses solely on the laboured transfers is the fluffy set's.

4.1 Identification of the fault section using information from circuit breakers

The fundamental security standards are:

- There should be a separate breaker for each piece of equipment that has any flaws.
- The remote reinforcement transfers need to go back to the breakers if any of the related transfers or breakers do not work. (ii)
- It is necessary to use backup breakers at level three if any or both of the level 1 or level 2 breakers fail to work.

In the event of a shortfall in a micro-community, the stumbling circuit breakers are the first to be examined. By focusing on just the stumbling circuit breakers in the conceivable deficiency section Ci, a frothy subset is formed.

$F_i^k\,(CB) = \{C_i, u^k\,(C_i)\}$

Where k = 1, 2, 3 signifies the first, second, third phase defense.

$u^k\,(C_i)$ is the association function toward measure the extent to which $\mathbf{C_i}$, be appropriate to RFO-NN set P_{fault} through allowing for solitary the kth phase slipped circuit breakers. Estimating a shortfall segment's enrollment potential helps determine its likelihood of becoming a deficiency location. Figure 6 depicts the circuit breaker linear fluffy enrollment process.

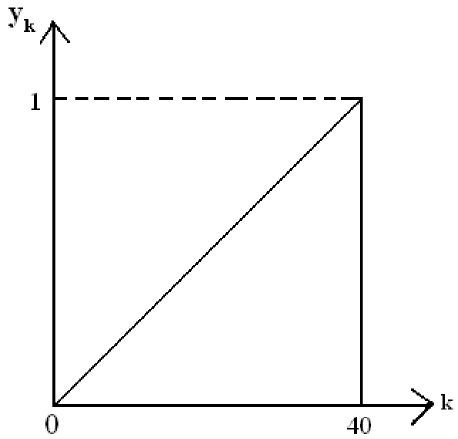

Figure. 6. RFO-NN membership for circuit breakers based on linear RFO-NN logic

Analysis

S1= whole number of segments got criticized

s_k= amount of buses or lines or else transformers got criticized

k=1 for buses

k=2 for lines

k=3 for transformer

n_k= total digit of circuit breakers tripped

k=1 for buses

k=2 for lines

k=3 for transformers

b_k= the quantity of primary, secondary, and tertiary circuit breakers that have tripped for each sector

where k=1, 2,3.

$$sumy_k = \sum_{k=1}^{b_k} y_k$$

y_k=membership function on behalf of the circuit breaker to activate at kth stage

By looking at circuit breakers, participants may determine how much of the deficient section has a fluffy set.

$u^k = r_k \times (sumy_k/b_k)$

where $r_{k=}$weight coefficient for every phase

$r_1=1$

$r_{2=}1-(sumy1/b_1)$

$r_3= (1-(sumy1/b_1)) \times (1-(sumy2/b_2))$

GA is used to compute the weight coefficients at each level, and the software is run on both the Micro-grid and the IEEE 33kV distribution networks.

Union of all tripped circuit breakers linked to a probable fault section Ci, Fi (CB) may be achieved by their union.

F_i (CB) = F_i^1 (CB) U F_i^2 (CB) U F_i^3 (CB)

= {C_i, Ucb (C_i)}

Ucb (C_i) = (u^1) U (u^2) U (u^3)

$= u^1 + u^2 + u^3 - (u^1 \times u^2) - (u^2 \times u^3) - (u^3 \times u^1) + (u^1 \times u^2 \times u^3)$

4.2 Spotting a problem section based on relay data

As long as everything else is working properly, circuit breakers may blow in certain instances. This is how the hand-off indication should be taken into account. Transfers are also protected by the RFO-NN subset and enrollment possibility linked with the possible difficulty location Ci.

F_i^k (RL) = {C_i, U^k (C_i)}

where k = 1, 2, 3 signifies the first, second, third phase security.

Uk (Ci) is an association function that determines the degree to which Ci may be used to RFO-NN set Pfault by allowing just the operating transmits of the kth stage protection to be used. Figure 7 shows the linear RFO-NN membership function for relays.

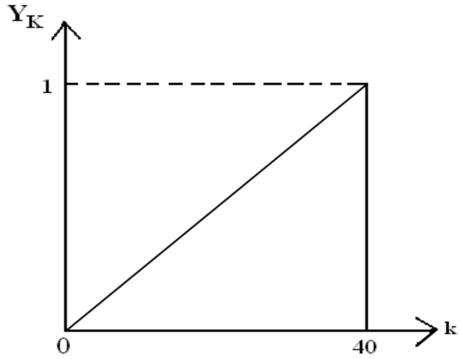

Figure. 7. RFO-NN linear relay membership

Analysis:

N_k= complete number of conveys tripped

k=1 for buses

k=2 for lines

k=3 for transformers

Bk=number of transmits activated at every phase (primary, secondary, tertiary) on behalf of every segment.

where k=1, 2, 3

$$SUMY_K = \sum_{K=1}^{B_K} Y_K$$

Y_K=connection function on behalf of the relay to control at K^{th} stage.

By considering relays, the membership function may be used to calculate the degree to which a responsibility segment belongs to a RFO-NN set.

$U^K = R_K \times (SUMY_K/B_K)$

Where R_K is weight coefficient.

GA is used to compute the weight coefficients at each level.

In order to accommodate the active protective relays, a liability set is constructed underneath**:**

$$F_i\,(RL) = F_i^1\,(RL)\ U\ F_i^2\,(RL)\ U\ F_i^3\,(RL)$$
$$= \{C_i,\ Url\,(C_i)\}$$
$$Url\,(C_i) = (U^1)\ U\ (U^2)\ U\ (U^3)$$
$$= U^1 + U^2 + U^3 - (U^1 \times U^2) - (U^2 \times U^3) - (U^3 \times U^1) + (U^1 \times U^2 \times U^3)$$

After completing the calculation of membership grades, the hypothesis of responsibility is formulated using (1)

$$Fi \quad = (Ficb)\ U\ (Firl)$$

$$U(C_i) = Ucb(C_i) + Url(C_i) - (\,Ucb(C_i) \times Url(C_i))$$

Using the Greatest assortment approach, the maximum likely fault section is always the one with the highest membership grade.

Maximum selection: The component that takes up the greatest membership grade space is the most likely to be faulty.

5. Results and Discussions

Table 1 displays the fault islands and tripped circuit breakers from IEEE33kV distribution network case studies 1 through 4. Table 1 shows buses as B1, B2, etc., lines as L1, L2 etc., and transformers as T1, T2 etc., all of which may be found there.

Table 1. An analysis of IEEE 33 kV distribution network fault islands

Case study	Circuit breakers tripped	Island
1	CB4,CB5,CB7,CB9,CB12,CB27	B1,B2,L2,L4
2	CB19,CB20,CB29,CB30,CB32, CB33,CB34,CB35,CB36,CB37,CB39	B7,B8,L5,L6,L7,L8,T7,T8
3	CB4,CB5,CB6,CB7,CB8,CB9, CB10,CB11,CB12	B1,B2,L1,L2
4	CB7,CB8,CB11,CB12, CB29,CB30,CB39,CB40	L1,L2,L7,L8

For each fault section, the findings of Case Study 1 are shown in Table 2, including the membership grade and the predicted error segment. Maximum assortment approach is used to calculate the maximum possible incorrect segment after calculating membership marks for all segments. A maximum membership grade of 0.8467 is used to calculate the estimated fault section B1.

Table 2. Results of IEEE 33kV case study 1

Possible fault sections	**Membership Grades**	**Circuit breakers tripped**	**Circuit breakers jammed**	**Estimated fault section**
B1	0.8467	CB4,CB5,CB7,CB9, CB12,CB27	CB6,CB8,CB10	B1
B2	0.8213	CB4,CB5,CB7,CB9, CB12,CB27	CB6,CB8,CB10	
L2	0.7197	CB4,CB5,CB7,CB9, CB12,CB27	CB6,CB8,CB10	
L4	0.7197	CB4,CB5,CB7,CB9, CB12,CB27	CB6,CB8,CB10	

Table 3 displays the findings from Case Study 2. B8, L5, T7, and T8 fault sections are the most likely candidates given the maximum membership grade of 0.9. Table 4 displays the findings from Case Study 3. Fault sections B1, B2, L1, and L2 are calculated based on a maximum membership grade of 0.9. Table 5 shows the results of case study 4. Fault sections L1, L2, L7, and L8 are calculated based on a maximum membership grade of 0.9.

Table 3. IEEE 33kV distribution system case study 2 results

Possible fault sections	**Membership Grades**	**Circuit breakers tripped**	**Circuit breakers jammed**	**Estimated fault section**
B7	0.8156	CB20,CB30,CB33, CB34,CB35	CB31,CB40	
B8	0.9	CB32,CB33,CB39	NO	B8
L5	0.9	CB19,CB32	NO	L5
L6	0.7305	CB20,CB30,CB33, CB34,CB35	CB31,CB40	
L7	0.9	CB29,CB39	NO	L7
L8	0.7305	CB20,CB30,CB33, CB34,CB35	CB31,CB40	
T7	0.9	CB34,CB36	NO	T7
T8	0.9	CB35,CB37	NO	T8

Table 4. IEEE 33kV case study 3 results

Possible fault sections	Membership Grades	Circuit breakers tripped	Circuit breakers jammed	Estimated fault section
B1	0.9	CB4,CB5,CB6, CB7,CB9,	NO	B1
B2	0.9	CB6,CB8,CB10	NO	B2
L1	0.9	CB7,CB11	NO	L1
L2	0.9	CB8,CB12	NO	L2

Table 5. IEEE 33kV case study 4 results

Possible fault sections	Membership Grades	Circuit breakers tripped	Circuit breakers jammed	Estimated fault section
L1	0.9	CB7,CB11	NO	L1
L2	0.9	CB8,CB12	NO	L2
L7	0.9	CB29,CB39	NO	L7
L8	0.9	CB30,CB40	NO	L8

Table 6 shows the fault islands and tripped circuit breakers in the Micro-Grid network from Case Studies 1–4. Table 7 shows the outcomes of the first case study. The highest membership grade of 0.85611 is used to estimate fault section B1. L5, T4 are also the projected fault sections in Case Study 2. Fault segment B3 has been approximated for the third case study. There are two possible fault sections in this case study: L1 and T1.

Table 6. Data on Micro-Grid fault islands

Case study	Circuit breakers tripped	Island
1	CB5,CB7,CB10,CB11	B1,L2,L3,L4
2	CB16,CB17,CB18,CB19	L5,T4
3	CB20,CB22,CB25,CB26	B3,L6,L7,L8
4	CB1,CB2,CB3,CB4, CB21,CB22,CB25,CB26	B3,L1,L7,L8,T1

Table 7. Findings from Micro-Grid network's first case study

Possible fault sections	Membership Grades	Circuit breakers tripped	Circuit breakers jammed	Estimated fault section
B1	0.85611	CB5,CB7,CB10,CB11	CB6,CB8,CB9	B1
L2	0.83091	CB5,CB7,CB10,CB11	CB6,CB8,CB9	
L3	0.83091	CB5,CB7,CB10,CB11	CB6,CB8,CB9	
L4	0.83091	CB5,CB7,CB10,CB11	CB6,CB8,CB9	

6. Conclusion

The most likely fault section in an IEEE 33 kV distribution network and a Micro-Grid network is estimated using a RFO-NN technique, which is presented in this study. As a result of this strategy, circuit breakers and laborious transfers will not lose their publish responsibility reputation. As a result, the database pales in comparison to the comprehensive database that depicts the complete assurance architecture. There are four main possibilities for the suggested strategy: less memory space, less PC time, a narrow range of ideas, and the framework's adaptability. Additionally, the RFO-NN expert system is much quicker and more precise than traditional expert systems.

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