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Power Distribution Self-Healing System Based on Intuitionistic Uncertainty-Rough Sets

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Abstract: General concern and numerous studies of smart grid make it explicit that self-healing feature is an essential condition of power system intellectualization. Existing self-healing system based on traditional intelligence algorithms can't simultaneously achieve satisfied effect and efficiency. To deal with the uncertainty factors and mass redundant data in the power system, rough set theory and intuitionistic fuzzy set theory are employed in this paper. And considering the excellent function of MAS which is a distributed and coupled network with different kinds of agents that can work together for a global goal, a multiagent self-healing system based on intuitionistic uncertainty-rough sets is proposed in this paper. The proposed method can enhance the control accuracy and simultaneously improve the decision-making efficiency. And the simulation result of a distribution system shows the excellent effect.

Keywords: Self-Healing, Rough Sets, Intuitionistic Fuzzy Sets, Intuitionistic Uncertainty-Rough Sets, Multiagent

1. Introduction

With increasing complexity and growing demand of the power system, it has a higher requirement of efficiency, reliability, security and energy sustainability. The concept of ”Intelligrid” has been put forward in this context to make an intelligent power system by a quantum leap in application of intelligent automation technology. ”Intelligrid” was first proposed by the U.S. Electric Power Research Institute in 2003 and then appeared a similar definition called ”Smart Grid” by the Europe Xcel Energy Institute in 2006 [1,2] . According to all definitions of the new intelligent power system and vast reaches in related fields, a smart grid is envisioned to take advantage of all modern technologies in transforming the conventional grid to one that with functions much more consummate [3] :

(1) Self-healing: A self-healing smart grid must have the capability of monitoring real-time state of system and responding to ambient interference and internal faults in order to complete fault diagnosis and system restoration rapidly with little or even none manual intervention. Through the self-healing control system, coverage and degree of power failure can be reduced effectively and even restraining of extensiveness blackout is realizable.

(2) Interactivity: Consumers will have the opportunity to choose not only the type of energy they receive but also with the ability to manage their own consumption habits through home automation by two-way communication with the smart power system.

(3) Compatibility: A large number of integration of renewable resources including solar and wind at levels from consumer premises to centralized plants to advance global energy sustainability.

(4) Majorization: It can provide higher power quality to not only satisfy common users but also meet the electricity demand of special industry. Furthermore, enhancement of efficiency by maximizing asset utilization is necessary.

(5) Security: The novel power system must has the characteristic of improving the ability of restraining attacks from cyber or physical by the dependablesystem fra-mework.

Consider all the characteristics of a smart grid, feature of self-healing has been a major focus area for the researching of modern grids. The intent of a self-healing grid is to use smart devices and components to monitor the environment, detect failures, notify appropriate officials and reroute the power to minimize the impact on consumers while the damaged components are repaired.

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As uninterrupted power supply is major principle of self-healing control, it includes three basic function: self-forecast, self-diagnosis and self-restoration [4] .There are some modern automatic technologies like Fast Simulation and Modeling, Wide Area Monitoring System, Advanced Distribution Automation, Demand Side Management and Intelligent Microgrid Technology contributing to construct a self-healing power system.

Due to the large scale and complexity of the Smart Grid, anticipating all possible scenarios that lead to performance lapses is difficult. Moreover, connection of lots of distributed generations make it much more complicated for fault diagnosis and recovery. A good deal of researches are proceeded about automatic self-healing control in distribution system. An agent-oriented architecture for a simulation were designed in [4] which can help in identifying ways to improve the electrical grid focus on the notion of self-healing. And an adaptive scheme is proposed in [5] aiming at achieving frequency and voltage stability through load shedding. Considering effects of distributed generations, a novel automation architecture which supports distributed multiagent intelligence, interoperability and enables efficient simulation of distributed automation systems is proposed in [6] based on IEC 61850/61499. But these studies have neglected the character of uncertainty from data acquisition to scheme execution in distribution system reconfiguration.

With the increasing complexity, there is a high degree of uncertainty in accurately estimating the impact of disruptions on the reliability, availability and efficiency of the power distribution system. These uncertainties result in hesitation on the part of decision makers in committing to smart systems for grid management. The uncertainty comes from the randomness of failures, fuzziness of data acquisition, rough feature caused by mass information redundancy, and uncertainty brought by lack of cognitive information. There are some relevant researches in fault diagnosis of distribution system and transformers with uncertainty [7,8] .

Consider rough sets' ability for complicated data reduction and good management skill of fuzzy sets for uncertain information, it's achievable to solve the problem of uncertainty factors in self-healing distribution system effectively referencing fuzzy rough sets and intuitionistic fuzzy sets [9–12] . At the same time, due to multi-agent system's advantages about concurrent computation and combination control, an adaptive self-healing system with it can reduce uncertainty factors' effect opportunely and improve the efficiency of the decision-making. According to them, this paper reports a novel self-healing procedure with multi-agent system using the intuitionistic uncertainty-rough sets which can make much contribution to data and attribute reduction and uncertainty compression.

The organization of this paper is as follows: Section 2 formulates the concept of intuitionistic uncertainty-rough sets and a reduction method based on compact computational domain. Section 3 describes the structure of a self-healing system upon intuitionistic uncertainty-rough set theory. Section 4 introduce the proposed multiagent self-healing system with the application of intuitionistic uncertainty-rough sets which helps make self-healing decisions. And section 5 provides the simulation results using a typical distribution power system with 69 nodes to prove the practicality and efficiency. Section 6 concludes the paper.

2. Intuitionistic Uncertainty-Rough Sets

A typical intuitionistic uncertainty-rough sets can be described as follows. The universe $U=\{x_i|i=1,\cdots,n\}$ is a nonempty set with n objects, $P=\{P_1,P_2,\cdots,P_p\}$ is a group of uncertainty condition attributes. Each attribute measures some important feature of the system and is limited to intuitionistic uncertainty linguistic terms $A(P_i)=\{F_{ik}|k=1,\cdots,C_i\}$. Each object $x_i\in U$ can be classified by a set of classes $A(Q)=\{F_l|l=1,\cdots,C_Q\}$, and Q is the decision attribute. Each $F_l\in A(Q)$ may be a certainty set or an uncertainty one. The set $U/P=\{F_{ik}|i=1,\cdots,p;k=1,\cdots,C_i\}$ can be regarded as a kind of partitions of U by a set of attributes P using intuitionistic uncertainty model.

Definition 1 (Membership Function and Nonmembership Function) *According to the lower and upper approximation compatibility functions for each intuitionistic uncertainty-rough sets, the membership function and nonmembership function are defined by*

$$\begin{cases} \mu_{\underline{A}}(F_{ik})=\inf_{x\in U}\max\{1-\mu_{F_{ik}}(x),\mu_A(x)\} \\ \chi_{\underline{A}}(F_{ik})=\sup_{x\in U}\min\{1-\chi_{F_{ik}}(x),\chi_A(x)\} \end{cases} \tag{1}$$

$$\begin{cases} \mu_{\overline{A}}(F_{ik})=\sup_{x\in U}\min\{\mu_{F_{ik}}(x),\mu_A(x)\} \\ \chi_{\overline{A}}(F_{ik})=\sup_{x\in U}\min\{\chi_{F_{ik}}(x),\chi_A(x)\} \end{cases} \tag{2}$$

From the equation (1), the region where $max\{1-\mu_{F_{ik}}(x),\,\mu_A(x)\}=1$ does not have any impact on the formation of lower approximation membership function due to "inf" operator on it. Computing of lower approximation membership degree is only on the region where $\max\{1-\mu_{F_{ik}}(x),\,\mu_A(x)\}\neq 1$. So consider the huge amount of calculation about the whole universe, we employ the concept of fuzzy-rough sets on compact computation domain proposed in [13], and got the membership and nonmembership function based on compact computation domain combining with intuitionistic fuzzy feature. The lower and upper membership function and nonmember one can be defined by

$$\mu_{\underline{A}}(F_{ik})=\begin{cases} \inf_{x\in D_{\underline{A}}(F_{ik})}\{\max[1-\mu_{F_{ik}}(x),\mu_A(x),\alpha]\} \\ \qquad\qquad \text{when } D_{\underline{A}}(F_{ik})\neq\emptyset; \\ 1 \qquad\qquad \text{when } D_{\underline{A}}(F_{ik})=\emptyset \end{cases} \tag{3}$$

$$\chi_{\underline{A}}(F_{ik}) = \begin{cases} \sup_{x\in B_{\underline{A}}(F_{ik})}\{\max[1-\chi_{F_{ik}}(x), \chi_A(x), \alpha]\} \\ \qquad\qquad \text{when } B_{\underline{A}}(F_{ik}) \neq \emptyset; \\ 1 \qquad\qquad \text{when } B_{\underline{A}}(F_{ik}) = \emptyset \end{cases} \tag{4}$$

$$\mu_{\overline{A}}(F_{ik}) = \begin{cases} \sup_{x\in D_{\overline{A}}(F_{ik})}\{\max\{\min[\mu_{F_{ik}}(x), \mu_A(x)], \beta\}\} \\ \qquad\qquad \text{when } D_{\overline{A}}(F_{ik}) \neq \emptyset; \\ 1 \qquad\qquad \text{when } D_{\overline{A}}(F_{ik}) = \emptyset \end{cases} \tag{5}$$

$$\chi_{\overline{A}}(F_{ik}) = \begin{cases} \sup_{x\in B_{\underline{A}}(F_{ik})}\{\max\{\min[\chi_{F_{ik}}(x), \chi_A(x)], \beta\}\} \\ \qquad\qquad \text{when } B_{\overline{A}}(F_{ik}) \neq \emptyset; \\ 1 \qquad\qquad \text{when } B_{\overline{A}}(F_{ik}) = \emptyset \end{cases} \tag{6}$$

where $0 \leq \alpha < \beta \leq 1$ is the lower and upper threshold in probability. $D_{\underline{A}}(F_{ik}) \in U$, $D_{\overline{A}}(F_{ik}) \in U$, $B_{\underline{A}}(F_{ik}) \in U$, $B_{\overline{A}}(F_{ik}) \in U$ are compact computational domains for lower and upper approximation membership functions of the intuitionistic uncertainty-rough sets are defined as

$$\begin{cases} D_{\underline{A}}(F_{ik}) = \left\{x \in U \,|\, \mu_{F_{ik}}(x) > \varepsilon \wedge \mu_{\underline{A}}(x) \neq 1, \exists\varepsilon > 0\right\} \\ D_{\overline{A}}(F_{ik}) = \left\{x \in U \,|\, \mu_{F_{ik}}(x) > \varepsilon \wedge \mu_{\underline{A}}(x) > \varepsilon, \exists\varepsilon > 0\right\} \end{cases} \tag{7}$$

$$\begin{cases} B_{\underline{A}}(F_{ik}) = \left\{x \in U \,|\, \chi_{F_{ik}}(x) > \varphi \wedge \mu_{\underline{A}}(x) \neq 0, \exists\varphi < 1\right\} \\ B_{\overline{A}}(F_{ik}) = \left\{x \in U \,|\, \chi_{F_{ik}}(x) > \varphi \wedge \mu_{\underline{A}}(x) < \varphi, \exists\varphi < 1\right\} \end{cases} \tag{8}$$

It is defined as intuitionistic uncertainty-rough sets based on compact computational domain, because of computing of $\{[\mu_{\underline{A}}(F_{ik}), \chi_{\underline{A}}(F_{ik})], [\mu_{\overline{A}}(F_{ik}), \chi_{\overline{A}}(F_{ik})]\}$ suffices to objects in compact computational domain instead of all $x \in U$. And $\varepsilon > 0$ is used to further narrow the calculation scope. The definition is consistent with that given in (1) and (2), but requires fewer numbers of computations for calculating lower and upper approximations. Compact computational domain can omit some unnecessary calculation and improve computing efficiency as it's subset of universe U.

Definition 2 (Membership Degree and Nonmembership Degree of Positive Region) *Membership degree and nonmembership degree of the intuitionistic uncertainty-rough sets' positive region which is classified by uncertainty linguistic terms F_{ik} according to Q are defined as*

$$\mu_{POS}(F_{ik}) = \sup_{F_l\in A(Q)} \{\mu_{\underline{F_l}}(F_{ik})\} \tag{9}$$

$$\chi_{POS}(F_{ik}) = \inf_{F_l\in A(Q)} \{\chi_{\underline{F_l}}(F_{ik})\} \tag{10}$$

And membership degree and nonmembership degree for $x \in U$ in the positive region can be defined as

$$\mu_{POS}(x) = \sup_{F_{ik}\in A(P_i)} \min\{\mu_{F_{ik}}(x), \mu_{POS}(F_{ik})\} \tag{11}$$

$$\chi_{POS}(x) = \inf_{F_{ik}\in A(P_i)} \max\{\chi_{F_{ik}}(x), \chi_{POS}(F_{ik})\} \tag{12}$$

Definition 3 (Dependency Degree and Nondependency Degree) *Dependency degree $\gamma_P(Q)$ and nondependency degree $\kappa_P(Q)$ of decision attribute Q on the sets of attributes P are defined by*

$$\gamma_P(Q) = \frac{\sum_{x\in U} \mu_{POS}(x)}{|U|} \tag{13}$$

$$\kappa_P(Q) = \frac{\sum_{x\in U} \chi_{POS}(x)}{|U|} \tag{14}$$

When make the reasoning $P \Rightarrow Q$, positive region of intuitionistic uncertainty sets U/Q inferred by Q can cover $\gamma_P(Q) \times 100\%$ of knowledge base $K = \{U, P\}$ and can't include $\kappa_P(Q) \times 100\%$. That means objects in $\gamma_P(Q) \times 100\%$ can be clustered by condition attributes P into intuitionistic uncertainty sets U/Q, and objects in $\kappa_P(Q) \times 100\%$ can't.

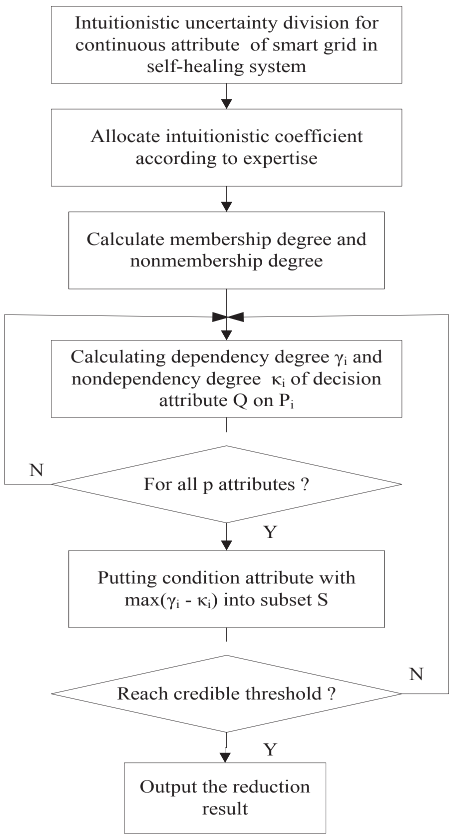

Figure 1 Reduction process of intuitionistic uncertainty-rough sets

Due to definition 3, dependency of decision attribute Q toward attribute sets P stands for importance of the attribute, the higher its dependency degree is the more important it is. Attribute reduction is on the basic of importance degree of the attributes, aiming at removing the attributes with less impact. A modified tree search algorithm is utilized in this paper by definition of intuitionistic uncertainty-rough sets and defining dependency and nondependency degree of decision on attribute sets. To begin with, the algorithm initializes the potential reduction to the empty set S, and add the more potential attribute with maximal $\gamma_P(Q)-\kappa_P(Q)$ to S with the change of dependency degree and nondependency degree. Let the object which with $\max\{\gamma_P(Q)-\kappa_P(Q)\}$ be the calculation origin of next level until the same dependency degree and nondependency degree are obtained in two neighbouring levels. The flowsheet of reduction is shown in figure 1.

As the reduction process based on intuitionistic uncert-ainty-rough sets shown in figure 1, attribute reduction in intuitionistic uncertainty-rough sets deals with dependency degree of decision attribute Q toward condition attribute set $P_i \in P$ to make redundant data deleting. Definition of compact computational domain helps improve the calculation efficiency as it is required to calculate only at first level of the search tree. At every subsequent level it can be calculated by iterative intersections. This method restricts the number of patterns to increase in multiplication with the Cartesian product of the cognition frame of selected sets. The new attribute sets after reduction must have the same information content with primal one, and dependency degree of each subset after reduction should tend to 1 as possible and nondependency one tends to 0.

3. Structure of Self-Healing System Based on Intuitionistic Uncertainty-Rough Sets

In order to establish the self-healing control system based on intuitionistic uncertainty-rough sets, condition attribute set includes voltage beyond-restriction degree, current beyond-restriction degree, frequency beyond-restriction degree, power-angle beyond-restriction degree and switch action degree. Simultaneously, decision attribute set consists of optimization control decision, preventive control decision, restorative control decision and emergency control decision. Then divide these attributes into different fuzzification semantics upon intuitionistic fuzzy set theory and calculate the membership degree and nonmembership degree of desired power system.

Definition of membership and nonmembership function about voltage beyond-restriction degree, current beyond-restriction degree, frequency beyond-restriction degree and power-angle beyond-restriction degree should take number of nodes with the problem of beyond-restriction and the beyond-restriction extent of each aberrant node in consideration. In addition, some uncertainty factors in a power system itself must be considered. Number of nodes with the problem of beyond-restriction can obtained by real-time information from data acquisition system, and the beyond-restriction extent of each aberrant node can be described by the ratio of real-time value to the upper limit of relevant attribute like voltage, current, frequency and power-angle. The uncertainty factors in a power system itself contain measurement error, data corruption in transmission and imperfection of algorithm. Current error, for example, is mainly composed of measurement error in current transformer and interference in communication system. Error caused by communication system is usually a random event as when it occurs and what influence it creates are uncertain, so a random variable is required to represent it. The error of current value and voltage value can be defined as:

$$\Delta I\% = (KI_2 - I_1)/I_1 \times 100\% = \varepsilon\% + \lambda_{i1}\Phi + \lambda_{i2}I_d \quad (15)$$

where Φ is the magnetic flux of current transformer, $\cos\varphi$ is the power factor, I_1 and I_2 are primary and secondary rated current and voltage, I_d is the short circuit current value, λ_{i1} and λ_{i2} are the coefficient, and $\varepsilon\%$ is the level error of the current mutual inductance which can be defined as follow

$$\varepsilon\% = \frac{100}{I_1} \times \sqrt{\frac{1}{T}\int_0^T K_1 i_2 - i_1)^2 dt} \quad (16)$$

where T is the period of short circuit current. For $\varepsilon\%$ can be described with different level, and there are four levels of 0.2, 0.5, 1 and 3 in China. In a distribution system, measurement amplitude error is often defined as $\pm 0.5\%$ and $\pm 1\%$, and phase error is $\pm 20^\circ$ and $\pm 40^\circ$, while level of mutual inductor is 0.5 or 1.

Switch action degree is the behaviour of breakers and protective relaying. A great number of acted switches mean a wider fault scope and a serious fault in the power system. In the same way, uncertainty about breakers and protective relaying also needs to be considered. Failure rate of breaker can be obtained as

$$\lambda_{Qi} = \lambda_Q + \lambda_L \frac{L}{100} + \lambda \quad (17)$$

where λ_Q is failure rate of itself which can be conducted as a stochastic disturbance, λ_L and λ respectively stands for the influence of distribution line and the bus, and L is length of the line. λ_L and λ can be obtained from experts' experience as they are concerned with electric distance between the device and the bus where it connects to, distributed generator and load nearby, and also location of failure. Due to the lower failure rate of protective relaying than breakers, we define the parameter of its main protection λ_{MR} 0.3 larger than breakers, 0.2 larger of local backup protection λ_{SR}, and 0.1 larger of remote backup protection.

4. Multiagent Self-healing System

Agent is an intelligent process based on characteristics of environment interpretation and ability of decision-making by itself to achieve global goal. Currently, agents are the focus of intense attention in many autocontrol fields and are used in an increasingly wide variety of applications. Application of multi-agent in power system control has been widely studied [14, 15]. In the smart grid framework, to process real time information from the environment and prevent, detect and handle faults, outages, and power flow issues, we require agents with differing roles that can adapt and cooperate to achieve global goals. With agents' features of heterogeneous and cooperative we need in the smart grid, agents are defined for monitoring the status of devices and other agents and power quality, completing computational tasks among available resources, information transfer of data and decision command, and performing negotiations related to power demand and supply exchanges within a microgrid [4].

Power systems are already use many agents such as protective relays, automatic voltage regulators and so on, however these simple agents do not take full advantage of the computing and communication technologies availably [14]. MAS is a distributed and coupled network of intelligent hardware and software agents that work together to achieve a global goal. It can make full use of advantages of single agent and make coordination control of all related agents. On the basis of the above superiorities of MAS, a three layers multiagent self-healing control system based on intuitionistic uncertainty-rough sets is proposed in this paper.

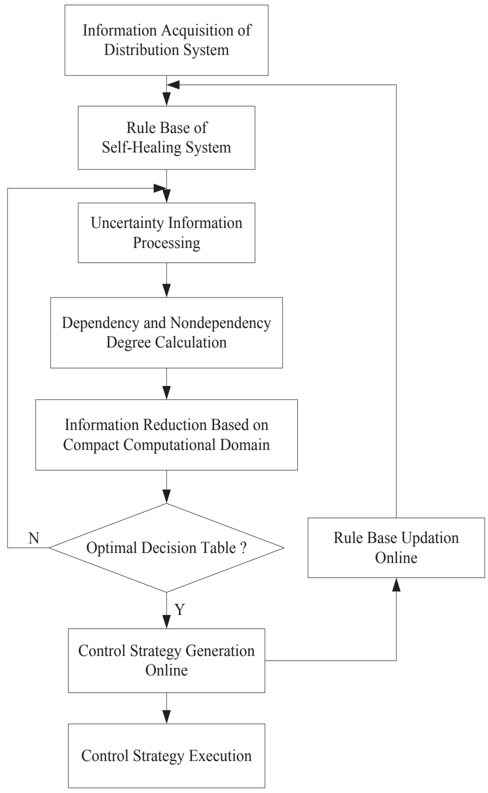

Figure 3 Self-healing flow diagram based on intuitionistic uncertainty-rough sets

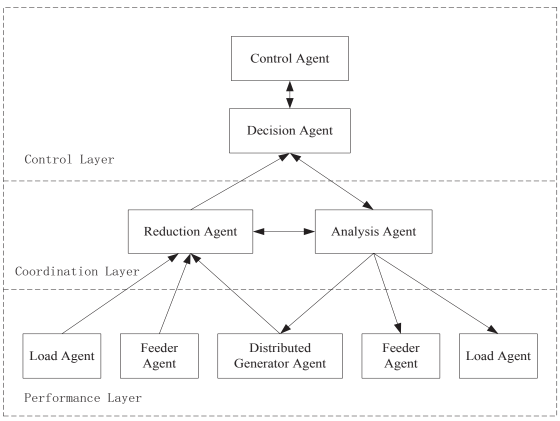

Figure 2 Multiagent self-healing system of distribution system

The three layers self-healing control system is presented in figure 2. The control system can be divided into three layers, control layer, coordination layer and performance layer.

1)Performance layer

The performance layer which consists of load agent, feeder agent and distributed generator agent is an organization to collect and monitor information of the system and execute control strategy. Data information will be upload to the reduction agent and these agents can get control decision from analysis agent. Different transmission channel can reduce the mutual interference of bidirectional communication and improve the efficiency and reliability in transmission. Noteworthily, distributed generator agent should not only have the basic function, but also can monitor real-time operational condition of DG to ensure eliminate its negative influence to the distribution system. As the installation position and installed capacity of DG can greatly influence the fault diagnosis and restoration, such as false tripping and even failure to operate of relaying devices, the distributed generator agent need a higher accuracy.

2) Coordination layer

This layer includes reduction agent and analysis agent. Reduction agent is used for data discretization, information obfuscation, membership function compute and data reduction based on intuitionistic uncertainty-rough set theory. The satisfied result of reduction will be upload to the decision agent to update self-healing control rule base. And analysis agent can conduct topology analysis, operation status identification and local control strategy analysis. It is also in charge of transmitting control command from the decision agent to performance layer.

3) Control layer

The layer is made by control agent and decision agent which is the core of a self-healing system. Decision agent receives the new reduction consequence from reduction agent to renew its rule base in order to ensure that the strategy providing to the smart grid corresponds to the real-time status. They will provide different control strategies when the distribution system is in different status, such as emergency control, restorative control, preventive control and optimization control.

Therefore, the flow diagram of a multiagent self-healing system based on intuitionistic uncertainty-rough sets is shown in figure 3.

5. Simulation

A simulation model of a distribution system with a distributed generation is used to evaluate the performance of the proposed method in self-healing decision making. Suppose a single phase to earth fault occures on the feeders, we use the multiagent self-healing system based on intuitionistic uncertainty-rough sets and the traditional decision making system to make control decision. Their behaviors are shown respectively in figure 4 and figure 5. Comparing these two results, the shorter time is used by the proposed method. Another model with cascading failure to simulate the situation that a serious single phase to earth fault develops into phase to phase fault is used to evaluate the performance of the proposed system. The implementation of a restorative control decision is shown in figure 6 which proves that the proposed method can also make a correct decision.

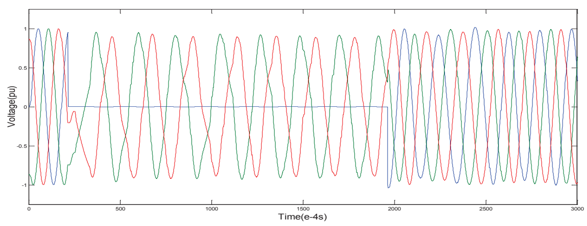

Figure 4 Restorative control decision making based on intuitionistic uncertainty-rough sets

To evaluate the practicality of the proposed system, the method is applied to a typical distribution power

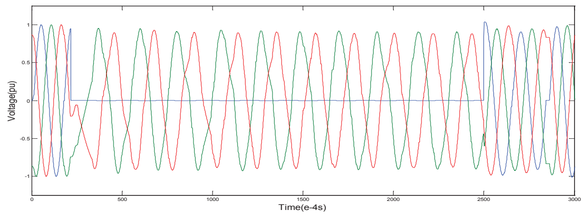

Figure 5 Restorative control decision making in traditional method

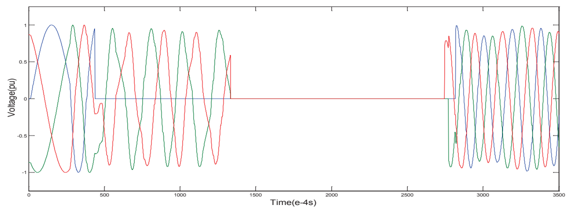

Figure 6 Restorative control of a cascading failure based on intuitionistic uncertainty-rough sets

system with 69 nodes which is shown in figure 7. There are 20 operable switches which are marked by "◯", and their current and voltage values are measurable. The condition attribute includes voltage beyond-restriction degree, current beyond-restriction degree, frequency beyond-restriction degree, power-angle beyond-restriction degree and switch action degree with total 23 semantics. And there is only one decision attribute with four semantics including emergency control, restorative control, preventive control and optimization control.

With 500 history records, the origin decision table can be established. In order to reduce calculation, ε of the compact computational domain is 0.2. In addition, to further revise the uncertainty in data acquisition device and transport process, the reduction ending condition is

$$\left|\gamma_{P(k+1)}(Q)-\kappa_{P(k+1)}(Q)\right|-\max\left|\gamma_{P(k)}(Q)-\kappa_{P(k)}(Q)\right|\leq 0.1 \tag{18}$$

Different control decision has different reduction results. For optimization control, there are 20 attributes after reduction and 6 percent of original information is reduced. For preventive control, there are 18 attributes after reduction and 9.8 percent of original information is reduced. For restorative control, there are 15 attributes after reduction and 14 percent of original information is reduced. For emergency control, there are only 9 attributes after reduction and 23 percent of original information is reduced. Summarize the test results, we use the exactness rate with different credible threshold to

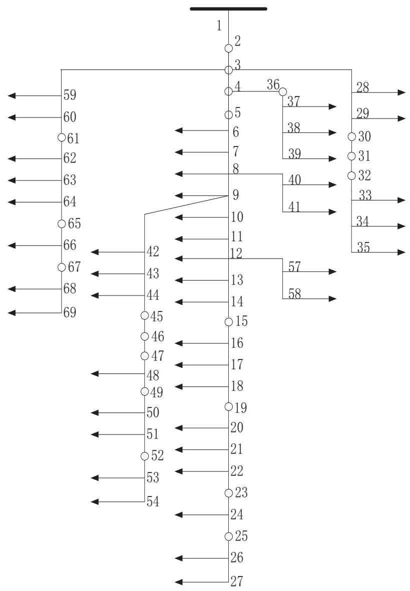

Figure 7 The typical distribution power system with 69 nodes

assess the proposed system and it's defined as

$$\gamma = [\sum_{\mu_i \geq \lambda, f_i = f_{test}} \text{card}(x_i) \cdot \mu_i \, / \sum_{\mu_i \geq \lambda} \text{card}(x_i) \cdot \mu_i] \quad (19)$$

where card(x_i) is the count of the rules. The test conclusion is shown in table 1.

Table 1 Conclusion of the test in a typical distribution power system

	Decision types			
σ	Optimization control	Preventive control	Restorative control	Emergency control
0.2	87.2%	76.1%	84.6%	90.6%
0.3	87.9%	79.6%	85.1%	91.2%
0.5	88.3%	83.5%	87%	94%

From the table, we can see the new self-healing system can usually make a correct decision. The optimal result is in emergency control decision making when the system is in an emergency condition and the problem of over-control is avoided.

6. Conclusion

Taking adverse effects caused by uncertainty information and problems of the too harsh boundary value in view, this paper propose a new self-healing system based on intuitionistic uncertainty-rough sets. The proposed method can help reduce the amount of information and increase the quality of information used in decision-making. Meanwhile, taking full advantage of compact computation domain can further help information reduction. In this article, the multiagent system and intuitionistic uncertainty-rough sets are combined to get a more excellent self-healing control system. To sum up, the multiagent self-healing system based on intuitionistic uncertainty-rough sets can enhance the control accuracy and simultaneously improve the decision-making efficiency. And the simulation result using this method of a distribution system indicates the excellent effect.

Acknowledgement

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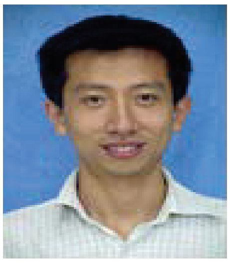

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