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Research of Power Online Security Auxiliary Decision System Based on Matlab Simulation

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Abstract: The parsing problems are due to the difference among COMTRADE standards, unreadable code in remote transmission and incompleteness of data in the power system. This paper presents an algorithm that can correctly parse the file in the Matlab format to the greatest extent. The algorithm includes the error pre-analysis part and the fault-tolerance parsing part. With the method of line-skipping parsing and validation, the error pre-analysis part can find all sorts of error that can influence the proper parsing and ultimately form an error information table. By inquiring the error information table and Matlab extension character table to parse the data file and obtain the validation information in advance, the fault tolerance parsing part reliably realizes fault-tolerance parsing of file in the Matlab format. Plentiful testing results of field data show that the new algorithm is practical and reliable, which can provide technical references to the development of any third-party transient data analysis software in a power system.

Keywords: Power Grid, Matlab, Online warning, Auxiliary decision, Data integration.

1. INTRODUCTION

In recent years, with the power grid spatial scale constantly expanding, the operation state of power grid has become more and more complex and the role of the online security early warning and auxiliary decision system of the power grid has become more and more important. The reliability of the system is the guarantee of safe and stable operation of power grid. High quality data source of the system plays complete role of the premise, and the quality of the data source depends on the effective combination of three constituents, which include the power network construction, state estimation and data integration [1]. Therefore, the study of grid network construction, state estimation and data integration is a very important and valuable work [2].

With the rapid development of new energy power generation and deepening of power grid interconnection, the grid structure is becoming increasingly complex and the operation modes have become more complicated [3-4]. All of these situations put safe and stable operation of power grid at unprecedented risk. Under these circumstances, local disturbance spreads to a large range at faster speed. Some faults of local grid might be propagated and transmitted quickly, which may result in cascading failures and then the blackouts, or even the breakdown of power system, which might bring a huge loss to the socio-economic and national life. Consequently, the effective early warning and control for cascading failures are the key to avoid blackouts. Brittleness theory of complex system is a new approach to analyze the cause, occurrence and propagation of cascading failures. From the perspective of system, it could analyze cascading failures of power system in terms of network, and ensure that the brittleness is not frequently inspired to cause blackouts as much as possible. The cascading failure warning model based on the brittleness theory of complex system is analyzed in this dissertation.

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2. TECHNOLOGY

The brittleness theory of complex system is introduced, giving a detailed mathematical and physical explanation. Characteristic analysis is proposed with the concepts of brittleness process and brittle element. The dissertation encompasses detailed description on typical brittle element forms and the brittleness of electric power system, which lays the foundation for further researches.

$$U_{ij} = \sum_{k=1}^{K} \lambda_k u_k(x_{ij}^k). \tag{1}$$

By taking full account of the uncertainty effects in the process of cascading failures [5], a fuzzy comprehensive evaluation model for brittle element of cascading failures is established. This model calculates the occurrence probability of brittle element based on the quantitative assessment value of the factors that affect cascading failures, and uses severity indexes to assess the severity of brittle element from system transient stability and load losses. Finally, it assesses and grades the risk of brittle elements using the fuzzy comprehensive evaluation method, which establishes the basis for cascading failure early warning combined with the interpretation of risk levels.

From the view that brittleness is the characteristic of power system, a brittle source identification model for cascading failures is proposed. This model analyses the mechanism of cascading failure by brittleness relevance and entropy increase, and then confirms initial faults of cascading

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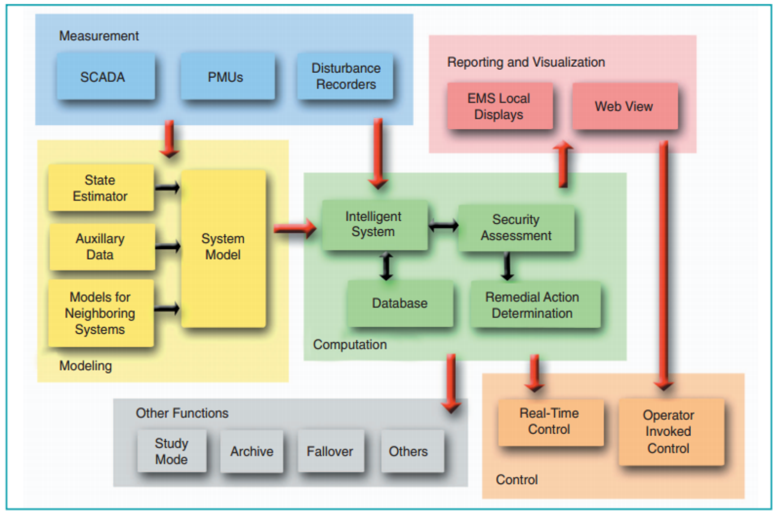


Fig. (1). The components of an online dynamic security assessment system.

failures by brittle degree, and lastly, uses brittle risk entropy to assess the impact of component outage on power grid operation and load removal. Meanwhile, this model [6] presents a process to find out the high-risk lines. Making a quick identification of brittle sources could reduce computation complexity greatly, and bring a more clear purpose for preventing cascading failure (Fig. **1**) [7].

$$E_i^p = \sum_{j=1}^{J} p_j U_{ij}, \quad i = 1, \ldots, I, \tag{2}$$

$$E_i^r = \max_i \{\min_j (U_{ij} p_j), \quad i = \overline{1, I}\}. \tag{3}$$

$$a_{i-m} E_i^p + (1 - a_{i-m}) E_i^r = a_{i-m} E_m^p + (1 - a_{i-m}) E_m^r \quad \text{for } i \neq m \tag{4}$$

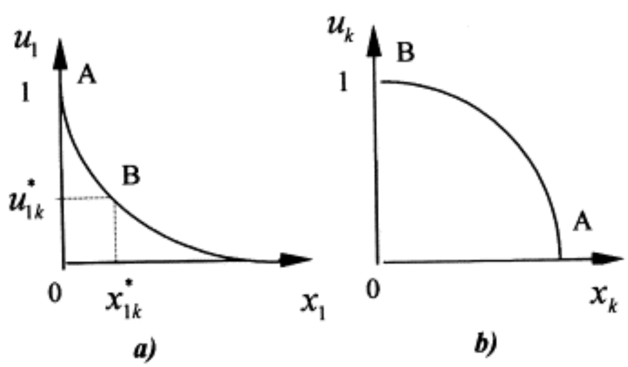


Fig. (2). Demonstration of algorithm.

Taking the line failure rate under severe weather into consideration, an early warning model based on brittleness theory of complex system is created combined with fuzzy comprehensive evaluation of brittle element of brittle sources. The model could give an early warning of brittle element in different risk level effectively, and provide intuitive basis for dispatchers to adjust operating modes and balance the power flow distribution (Fig. **2**).

3. MODEL

Analyzing that the failure-state information in different stages of cascading failures cannot be mastered, a model to defense cascading failures in complex power grid based on multistage games with incomplete information is proposed. It is proposed to characterize the effects of component faults on power grid under incomplete information by the accident state index. Combining with game theory, the proposed model recognizes the offensive side's current strategy during different courses of cascading failures and obtains the payoff function. According to the payment function values, the defensive side takes appropriate defense strategy by calculating the DC power flow sensitivity matrix and load node voltage sensitivity matrix. The proposed model provides direct and accurate evidences for adjustment measures at the initial stage of cascading failures and emergency control measures at the rapid spreading stage (Fig. **3**).

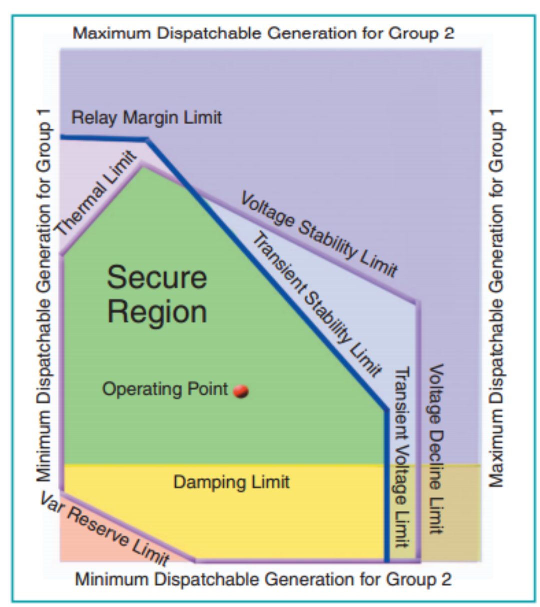


Fig. (3). Security monogram showing a secure region in which the operator can maneuver the system without encountering operating criteria violations.

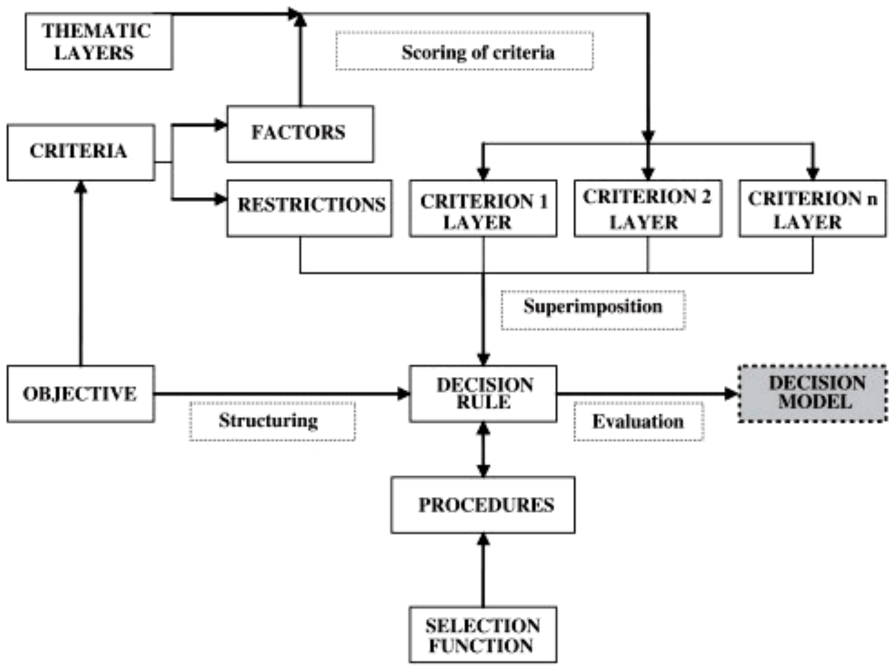


Fig. (4). Flow chart of the elaboration of the decision model.

The cascading failures and power grid lack of effective early warning cannot grasp the stability of power grid ortake effective control measures when some local small fault has not been timely and effectively treated, or some of the existing power grid security risks have not been realized and given attention. Consequently, this spreads to a large range, leading to runaway accident of power grid. Therefore, cascading failure early warning model is designed to forecast and master the power grid safe operation state to judge the potential danger and minimize the developing trend of accidents to provide an important decision basis for improving the security and stability of power grid operation level (Fig. **4**).

3.1. Objective of the Method

In this paper, the uncertainties of the chain faults and the brittle correlation degree of the components during the fault evolution are considered, and the fuzzy comprehensive evaluation method of the brittle element of cascading failures is proposed. Evaluation of the method of quantitative brittle basic element influencing factors of value is used to calculate the brittle basic element of the probability of occurrence of a fuzzy behavior index system from the system transient stability and load loss. Two aspects of quantitative assessment of the severity of brittle basic element consequences combined with fuzzy comprehensive evaluation model of brittle basic element of risk assessment and interpretation of the risk rating are given and brittle basic element of risk classification is proposed. Based on this, considering the impact of bad weather on the brittleness of the grid, cascading failure warning model based on Brittleness Theory of complex system was established. A simulation example verified the validity and practicability of the early-warning model.

3.2. Definition of Criteria

According to the previous studies, modern power grid blackout is mainly caused by cascading failures; cascading failures occurred in the presence of complex causes and diffusion mechanism. Domestic and foreign scholars conducted extensive research on the cascading failure evaluation and prediction . Regarding this, this article also from the perspective of power system brittle, proposed the early warning model of cascading failures; however, regardless of whatever factors triggered cascading failures, in any grid, there exists a certain probability of these failures, and in actual operation, eventually leads to serious consequences, or even a blackout which is often caused by imperfect defense measures. Therefore, cascading failure analysis, assessment and early warning are eventually required for appropriate means of control to the safe operation of power grid. In this regard, defense cascading failures model research for the prevention and control of cascading failure is particularly important (see Table **1** for a list of the factors defined for each criterion).

4. DEFINITION OF THE DECISION RULE

Generally speaking, in the typical cascading failure of power system, initial fault phase and fault trigger certainly exist. Initial fault stage usually consists of multiple component failures. Every fault, although had a longer time interval, but a spate of the power grid operation state continued to deteriorate in this process, triggering fault, leading to network elements in a chain reaction. From the first failure of the grid to the system, blackout process can be described as the process of spreading from the initial fault to the local, and then by the local spread to the entire power grid process (Fig. **5**).

Table 1. Positive and negative indicators.

Criteria	Factors	Indicators
Environment	Land use	Area without vegetation
		Dryland herbaceous crops
		Irrigated herbaceous crops
		Herbaceous and woody crops
		Woody crops
		Other uses
	Visual impact	Areas with minimum-value scenery
		Areas with value-2 scenery
		Areas with value-3 scenery
		Areas with value-4 scenery
		Areas with value-5 scenery
		Areas with value-6 scenery
		Areas with value-7 scenery
		Areas with value-8 scenery
		Areas with value-9 scenery
		Areas with maximum-value scenery
Orography	Slopes	<3%
		4%–6%
		7%–9%
		10%–12%
		14%–16%
		17%–19%
		20%–22%
		24%–26%
		26%–28%
		29%–31%
		>31%
	Orientation	South
		Southeast
		Southwest
		East
		West

Table 1. contd…

Criteria	Factors	Indicators
		Northeast
		Northwest
		North
Location	Highway access	<1.5km
		1.5–2.5km
		2.5–3.5km
		>4km
	Distance to substations	<1.5km
		1.5km–2.5km
		2.5km–12km
		>12 km
	Distance to urban areas >5000 inhabitants	<6 km
		6 km–12 km
		>12 km
	Distance to urban areas <5000 inhabitants	<1.5 km
		1.5 km–7 km
		>7 km
Climate	Global irradiance	4227–4452 Wh/m^2/day
		4576–4755 Wh/m^2/day
		4756–4755 Wh/m^2/day
		4575–4897 Wh/m^2/day
		4782–4454 Wh/m^2/day
		4124–4451 Wh/m^2/day
		4896–4946 Wh/m^2/day
		4972–5075 Wh/m^2/day
		5411–5783 Wh/m^2/day
	Diffuse radiation	0.21%
		0.25%
		0.26%
		0.45%
		0.78%
		0.78%

Table 1. contd…

Criteria	Factors	Indicators
	Equivalent sun hours (ESH)	4575–7575Kwh/Kwp
		7521–5431Kwh/Kwp
		5421–4752Kwh/Kwp
		4512–4574Kwh/Kwp
		2721–3571Kwh/Kwp
		4175–4511Kwh/Kwp
		4574–1278Kwh/Kwp
		78654–17854Kwh/Kwp
		4575–7541Kwh/Kwp
	Average temperature	16.2–16.8 °C
		16.8–17.4 °C
		18.4–18.0 °C
		16.0–16.6 °C
		18.6–19.9 °C
		19.3–19.9 °C
		19.9–20.5 °C
		21.5–22.1 °C
		22.1–25.7 °C

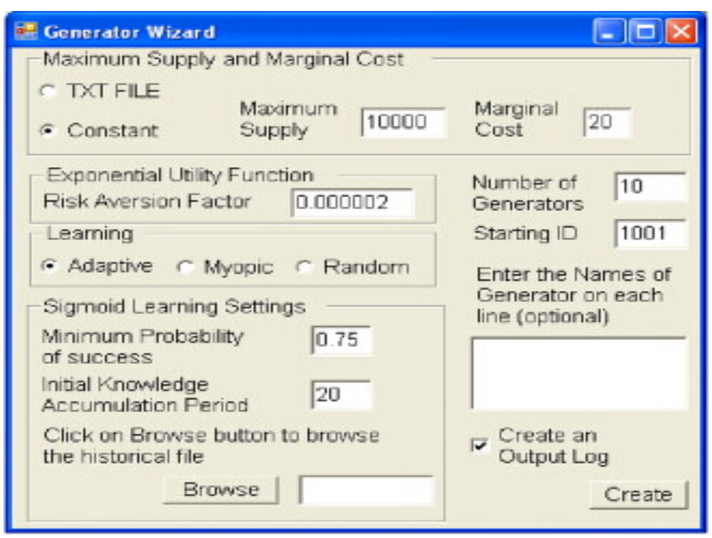
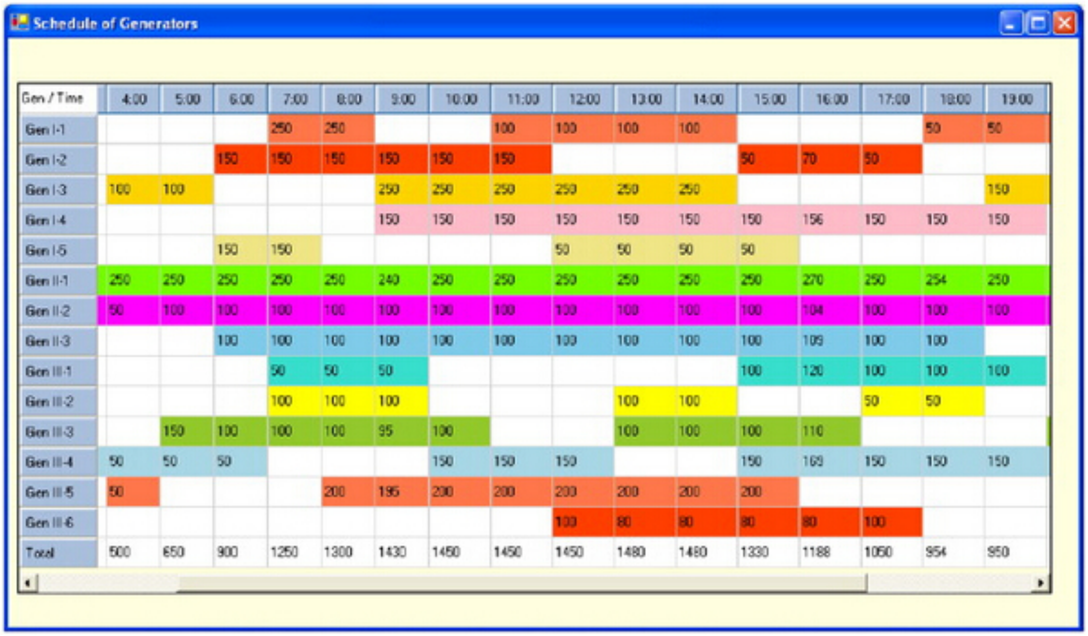


Fig. (5). Generator creation wizard based on Matlab.

The fault occurs mostly in the area adjacent to the initial fault. The development of the initial failure often occurs in the interaction between the components that affect each other and not random components. Components of the system load rate and network structure of the load capacity are a pair of contradiction. The initial fault grid in component failure trips, grid load capacity decreases, the trend of residual grid aggravates, and curse of elements is strengthened in the alloy. In the initial stages of failure and for cascading failures in the brittle source identification, brittle basic element of fuzzy



Schedule of Generators

Gen / Time	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00
Gen I-1				250	250			100	100	100	100				50	50
Gen I-2			150	150	150	150	150	150				50	70	50		
Gen I-3	100	100				250	250	250	250	250	250					150
Gen I-4						150	150	150	150	150	150	150	156	150	150	150
Gen I-5			150	150					50	50	50	50				
Gen II-1	250	250	250	250	250	240	250	250	250	250	250	250	270	250	254	250
Gen II-2	50	100	100	100	100	100	100	100	100	100	100	100	104	100	100	100
Gen II-3			100	100	100	100	100	100	100	100	100	100	109	100	100	
Gen III-1				50	50	50						100	120	100	100	100
Gen III-2				100	100	100				100	100			50	50	
Gen III-3		150	100	100	100	95	100			100	100	100	110			
Gen III-4	50	50	50				150	150	150			150	169	150	150	150
Gen III-5	50				200	195	200	200	200	200	200	200				
Gen III-6									100	80	80	80	80	100		
Total	500	650	900	1250	1300	1430	1450	1450	1450	1480	1480	1330	1188	1050	954	950

Fig. (6). Computer monitor for dispatch scheduling based on Matlab.

comprehensive evaluation based on this warning is to avoid triggering breakdown of prevention and control, providing an intuitive basis (Fig. **6**).

Multi - stage strategy includes the human, strategy set and payment function in the multi - stage of cascading failures:

1) The board: includes the offensive side and the defensive side. The disturbance is defined as the offensive side i.e., the security device.

The dispatcher is defined as a defensive side. Multi-stage strategy is for cascading failures and countermeasures for two people.

2) Strategy set: before the end of cascading failures, the offensive strategy sets grid disturbance of severity of different types and grid includes the limit state; defense strategy set includes Ann from device action and dispatches personnel to take decisions and measures.

3) The payment function: the payoff function of the offensive side is comprised of load severity, voltage sag severity, and power angle stability margin and causes loss of load of four parts: the defending revenue loss of load.

$$S = \left\{\frac{1}{9}, \frac{1}{8}, \frac{1}{7}, \frac{1}{6}, \frac{1}{5}, \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, 1, 2, 3, 4, 5, 6, 7, 8, 9\right\} \quad (5)$$

In the whole process of cascading failures, it is not possible to fully grasp the fault at all stages of the accident state information, and for defense cascading failure, the need to obtain information in addition to the currently running electric quantity of state of system description, the most important is understanding of component failure on the system caused by impact, the current power grid stability margin and adopting defense by the most effective measure. Therefore, the impact of the fault state index on measuring the failure of the component and the defense measures is defined as the severity of the load, the severity of the bus voltage and the stability margin of the power angle.

CONCLUSION

In this paper, firstly, the online security early warning and auxiliary decision system of power grid was studied, and the function of the software platform support system was analyzed along with the function of the application of the system . Secondly, according to the characteristics of the power grid, the construction scheme of power grid network was studied, and the proposed scheme was carried on the simulation analysis by MATLAB software. The scheme proposed by MATLAB software verifies the feasibility of power grid network construction scheme. Power grid network construction scheme greatly simplifies the scale of network building. At the same time, a method of improving the qualified rate of state estimation debug was put forward Moreover, a new ring circuit parameters estimation based on matrix computation practical method and the corresponding verification which can improve the precision of estimation of power grid were also proposed. Finally, power grid online security early warning and auxiliary decision system data integration solution was studied, presenting an improved data integration solution based on the characteristics of grid.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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