

The Weighting Analysis of Influence Factors in Gas Breakdown via Rough Set and GM(h,N)

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Abstract—In power system filed, to study the characteristics of the gas breakdown is essential and of importance in designing the protection of high voltage system as well as to the power system reliability. Hence, in this paper, the major purpose is to propose a refined mathematical approach based on core finding in rough set method and GM(h,N) method in grey system theory to find the priority of influence factor in gas breakdown. And also created rough set and GM(h,N) toolbox based on Matlab, which to help the complex calculation and analysis. As the result, we not only can get the rank of influence factor in gas breakdown, but also provides a new idea for extension the applications of rough set and GM(h,N) method.

Index Terms—gas breakdown, rough set, GM(h,N) influence factor, Matlab toolbox

I. INTRODUCTION

According to the study conducted by the Taipower Company, more than 50% of the power outages are caused by high voltage (current) breakdown. Among these outages, the main cause is the gas breakdown. Therefore, it is essential to study the characteristics of the gas breakdown and it is important to design protection for these high voltage systems as well as study the power system reliability. Although the causes of gas breakdown are still not very clear, the gas breakdown is a discharge phenomenon based on the experiences and experiments conducted previously. Besides, some factors that may be relevant to the breakdown have been inferred. Based on the textbook on high voltage, the properties of gas breakdown can be summarized in a few items: The break voltage is up to thunder kilo voltage; The discharge path can be extended into 10 kilometer order; The range of ground surface potential gradient before breakdown is 30kV/cm ~100kV/cm; The current is up to thunder kilo ampere; The gap of gas breakdown is larger than normal value and the density of gas is non-homogenous[1].

Considering the properties of gas breakdown in gas, and several practical experiments, the taken selection can be from the most important characteristics of the breakdown in gas as: The ground surface potential

gradient: ∇V ; The ratio of the ground surface potential gradient and time: $\frac{d\nabla V}{dt}$; The atmospheric pressure (torr);

The relative humidity (%); The variety of gas (compressed or mixed); The polarity of current; Temperature and Frequency. Although these factors seem to be independent of each other, during the gas breakdown, their values have a range of influence and are correlated to the gas breakdown. The development of an analytical mathematical model to interpret the correlation between these factors and the gas breakdown is thus crucial to the study.

Dr. Pawlak presented the rough set in 1982, the basic topics of rough set includes: set theory; conditional probability; membership function; attributes analysis and uncertainty description of knowledge[2~6]. And the main purpose of rough set is used the difference of lower approximations and upper approximations, to find out the subjective result of clustered set.

The Grey System Theory, first proposed by Professor Julong Deng in 1982[7], avoids the inherent defects of conventional, statistical methods and only requires a limited amount of data to estimate the behavior of an uncertain system. The field of the grey system can be summarized in six parts: Grey relational generating operation (GRGO); Grey Relational Analysis (GRA): Includes localization grey relational grade (LGRG) and globalization grey relational grade(GGRG); Grey Model (GM); Grey Decision Making and Grey Control[7]. In summary, the main purpose of the grey system theory focuses on the relation between the analysis model construction, and for circumstances such as: no certainty, multi-data input, discrete data, and insufficient data through predicting and decision-making.

Based on the mentioned above, we find that rough set and GM(h,N) model are very satisfy for study in the influence factor in gas breakdown. And review the past research, only few papers are focus on this topics, but all focus on the accuracy of gas breakdown times and its phenomenon [8~12]. Hence, in our research, we present rough set and GM(h,N) model to find the major influence factor in gas breakdown, it is a new approach in the high voltage system[13,14].

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In this paper, first, we list the whole mathematical foundation of rough set and GM(h,N) model in section II and section III. In section IV, the experiment of gas breakdown is given and the data is also found. In section V, the development of rough set and GM(h,N) toolbox via GUI method in *Matlab* are presented. Also in section VI, we make some advantages and suggestions for the further research.

II. ROUGH SET

In this section, we only simply introduce the basic concept of rough set[15].

A. Basic relationship

1.Information system, IS

$IS = (U, A)$ is called information system, where $U = \{x_1, x_2, x_3, \dots, x_n\}$ is the universe finite set of object, and $A = \{a_1, a_2, \dots, a_m\}$ is the set of attribute.

2. Information function

If exist a mapping $f_a : U \rightarrow V_a$, then V_a is the set of value of a , call the domain of attribute a .

3..Indiscernibility relation

For every set of attributes B; A, an indiscernibility relation $Ind(B)$ is defined in the following way: two objects, x_i and x_j , are indiscernible by the set of attributes B in A, if $b(x_i) = b(x_j)$ for every $b \in B$. The equivalence class of $Ind(B)$ is called elementary set in B because it represents the smallest discernible groups of objects. For any element x_i of U, the equivalence class of x_i in relation $Ind(B)$ is represented as $[x_i]_{Ind(B)}$.

B. Calculation method

1.Lower approximations

If $A \subseteq U$, then the lower approximations is defined as

$$\underline{R}(A) = \{x \in U \mid [x]_R \subseteq A\} = \bigcup \{[x]_R \in \frac{U}{R} \mid [x]_R \subseteq A\} \quad (1)$$

in which $[x]_R = \{y \mid xRy\}$

2. Upper approximations

If $A \subseteq U$, then the upper approximations is defined as

$$\overline{R}(A) = \{x \in U \mid [x]_R \cap A \neq \emptyset\} = \bigcup \{[x]_R \in \frac{U}{R} \mid [x]_R \cap A \neq \emptyset\} \quad (2)$$

in which $[x]_R = \{y \mid xRy\}$

3.Boundary

The boundary of A is defined as

$$bn_R(A) = \underline{R}(A) - \overline{R}(A) \quad (3)$$

4.Dispensable

U is equivalent relationship, and $A \in U$, if

$$ind(U) = ind(U - A) \quad (4)$$

then A is called dispensable in U.

5.Independent

U is equivalent relationship, and $A \in U$, if

$$ind(U) \neq ind(U - A) \quad (5)$$

then A is called independent in U.

6.Reduce

For $U \subseteq A$ is independent and

$$ind(U) = ind(A) \quad (6)$$

Then A is reduced in U.

7.Positive and Negative

$$pos_R(X) = \underline{R}(X), \quad neg_R(X) = U - \overline{R}(X) \quad (7)$$

C. The dependents of attributes

$$\gamma_c(D) = \frac{|posc(D)|}{U} \quad (8)$$

Means under $a \in C$, the ratio in the whole set

D. The significant value of attributes

In decision system, $S = (U, C \cup D, V, f)$, under $a \in C$, the significant value of attributes is defined as

$$\sigma_{(C,D)}(a) = \frac{\gamma_c(D) - \gamma_{c-\{a\}}(D)}{\gamma_c(D)} = 1 - \frac{\gamma_{c-\{a\}}(D)}{\gamma_c(D)} \quad (9)$$

E. Core

If the set of attributes is dependent, one can be interested in finding all possible minimal subsets of attributes, which lead to the same number of elementary sets as the whole set of attributes reduce and in finding the set of all indispensable attributes.

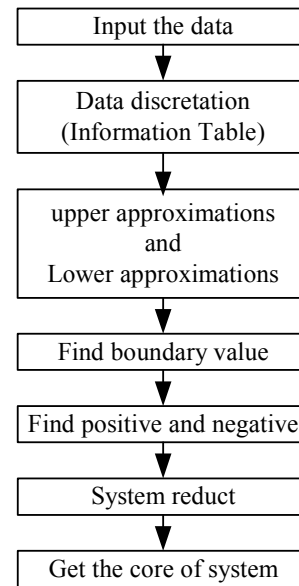


Figure 1. The operation of core in rough set method

III. GM(H,N) MODEL

In grey system theory, the main function of GM(h,N) model of the grey theory system is a method to carry out the calculation of measurement among the discrete sequences and to compensate the shortcomings in the traditional methodology. The GM(h,N) model is defined as[8]

$$\sum_{i=0}^h a_i \frac{d^{(i)}x_1^{(1)}}{dt^{(i)}} = \sum_{j=2}^N b_j x_j^{(1)}(k) \quad (10)$$

where: a_i and b_j are determined coefficients.

- ii. $x_1^{(1)}(k)$: The major sequence.
- iii. $x_j^{(1)}(k)$: The influencing sequences.
- iv. AGO $x^{(0)} = x^{(1)}$
 $= [\sum_{k=1}^1 x^{(0)}(k), \sum_{k=1}^2 x^{(0)}(k), \sum_{k=1}^3 x^{(0)}(k), \dots, \sum_{k=1}^n x^{(0)}(k)]$

A. GM(1,N) Model

If in sequences $x_i^{(0)}(k)$, $i=1,2,3,\dots,N$, $x_1^{(0)}(k)$ is the main factor in the system, and sequences $x_2^{(0)}(k), x_3^{(0)}(k), x_4^{(0)}(k), \dots, x_N^{(0)}(k)$ are the influence factors, then we can use GM(1,N) to analyze the system, the GM(1,N) model is shown below.

$$x_1^{(0)}(k) + a_1 z_1^{(1)}(k) = \sum_{j=2}^N b_j x_j^{(1)}(k) \quad (11)$$

where: $k = 1,2,3,\dots,n$, the analytical steps are shown below.

1. Building the original sequences

$$\begin{aligned} x_1^{(0)} &= (x_1^{(0)}(1), x_1^{(0)}(2), \dots, x_1^{(0)}(k)) \\ x_2^{(0)} &= (x_2^{(0)}(1), x_2^{(0)}(2), \dots, x_2^{(0)}(k)) \\ x_3^{(0)} &= (x_3^{(0)}(1), x_3^{(0)}(2), \dots, x_3^{(0)}(k)) \\ &\dots\dots\dots \\ x_N^{(0)} &= (x_N^{(0)}(1), x_N^{(0)}(2), \dots, x_N^{(0)}(k)) \end{aligned} \quad (12)$$

where: $k = 1,2,3,\dots,n$

2. Building the AGO sequences

$$\begin{aligned} x_1^{(1)} &= (x_1^{(1)}(1), x_1^{(1)}(2), \dots, x_1^{(1)}(k)) \\ x_2^{(1)} &= (x_2^{(1)}(1), x_2^{(1)}(2), \dots, x_2^{(1)}(k)) \\ x_3^{(1)} &= (x_3^{(1)}(1), x_3^{(1)}(2), \dots, x_3^{(1)}(k)) \\ &\dots\dots\dots \end{aligned} \quad (13)$$

$$x_N^{(1)} = (x_N^{(1)}(1), x_N^{(1)}(2), \dots, x_N^{(1)}(k))$$

where: $k = 1,2,3,\dots,n$

3. Combining the AGO sequences with the major sequence, and substituting all AGO values into equation (13)

$$\begin{aligned} x_1^{(0)}(2) + az_1^{(1)}(2) &= b_2 x_2^{(1)}(2) + \dots + b_N x_N^{(1)}(2) \\ x_1^{(0)}(3) + az_1^{(1)}(3) &= b_2 x_2^{(1)}(3) + \dots + b_N x_N^{(1)}(3) \\ &\dots\dots\dots \end{aligned} \quad (14)$$

$$x_1^{(0)}(n) + az_1^{(1)}(n) = b_2 x_2^{(1)}(n) + \dots + b_N x_N^{(1)}(n)$$

where: $z_1^{(1)}(k) = 0.5x_1^{(1)}(k) + 0.5x_1^{(1)}(k-1)$, $k \geq 2$

then, transform the equation into matrix form.

$$\begin{bmatrix} x_1^{(0)}(2) \\ x_1^{(0)}(3) \\ \vdots \\ x_1^{(0)}(n) \end{bmatrix} = \begin{bmatrix} -z_1^{(1)}(2) & x_2^{(1)}(2) & \dots & x_N^{(1)}(2) \\ -z_1^{(1)}(3) & x_2^{(1)}(3) & \dots & x_N^{(1)}(3) \\ \vdots & \dots & \dots & \dots \\ -z_1^{(1)}(n) & x_2^{(1)}(n) & \dots & x_N^{(1)}(n) \end{bmatrix} \begin{bmatrix} a \\ b_2 \\ \vdots \\ b_N \end{bmatrix} \quad (15)$$

4. By using the matrix method $\hat{a} = (B^T B)^{-1} B^T Y_N$ to find the values of b_N .

$$\text{where: } Y_N = \begin{bmatrix} x_1^{(0)}(2) \\ x_1^{(0)}(3) \\ \vdots \\ x_1^{(0)}(n) \end{bmatrix}, \hat{a} = \begin{bmatrix} a \\ b_2 \\ \vdots \\ b_N \end{bmatrix}$$

$$B = \begin{bmatrix} -z_1^{(1)}(2) & x_2^{(1)}(2) & \dots & x_N^{(1)}(2) \\ -z_1^{(1)}(3) & x_2^{(1)}(3) & \dots & x_N^{(1)}(3) \\ \vdots & \dots & \dots & \dots \\ -z_1^{(1)}(n) & x_2^{(1)}(n) & \dots & x_N^{(1)}(n) \end{bmatrix}$$

Hence, the relationship between the major sequence and the influencing sequences can be found by comparing the values of b_N .

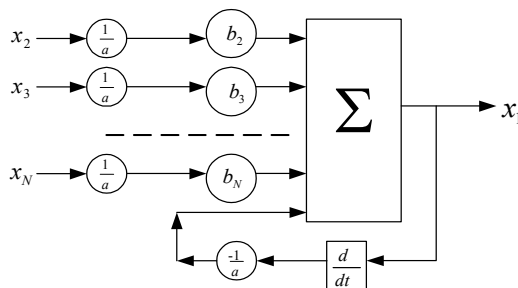


Figure 2. GM(1,N) model concept

B. GM(0,N) Model

The GM(0,N) model is the special state in the of GM(h,N) model, the function is the same as the GM(1,N) model. According to the definition of GM (0,N) model.

$$\begin{aligned} az_1^{(1)}(k) &= \sum_{j=2}^N b_j x_j^{(1)}(k) \\ &= b_2 x_2^{(1)}(k) + b_3 x_3^{(1)}(k) + \dots + b_N x_N^{(1)}(k) \end{aligned} \quad (16)$$

where:

$$z_1^{(1)}(k) = 0.5x_1^{(1)}(k-1) + 0.5x_1^{(1)}(k), \quad k = 2,3,4,\dots,n$$

1. Substituting the AGO value, then we have

$$\begin{aligned} a_1 z_1^{(1)}(2) &= b_2 x_2^{(1)}(2) + \dots + b_N x_N^{(1)}(2) \\ a_1 z_1^{(1)}(3) &= b_2 x_2^{(1)}(3) + \dots + b_N x_N^{(1)}(3) \\ a_1 z_1^{(1)}(4) &= b_2 x_2^{(1)}(4) + \dots + b_N x_N^{(1)}(4) \\ &\dots\dots\dots \\ a_1 z_1^{(1)}(n) &= b_2 x_2^{(1)}(n) + \dots + b_N x_N^{(1)}(n) \end{aligned} \quad (17)$$

2. Dividing a_1 in both sides, then translate into matrix form

$$\begin{bmatrix} 0.5x_1^{(1)}(1) + 0.5x_1^{(1)}(2) \\ 0.5x_1^{(1)}(2) + 0.5x_1^{(1)}(3) \\ \vdots \\ 0.5x_1^{(1)}(n-1) + 0.5x_1^{(1)}(n) \end{bmatrix} = \begin{bmatrix} x_2^{(1)}(2) & \dots & x_N^{(1)}(2) \\ x_2^{(1)}(3) & \dots & x_N^{(1)}(3) \\ \vdots & \dots & \vdots \\ x_2^{(1)}(n) & \dots & x_N^{(1)}(n) \end{bmatrix} \begin{bmatrix} b_2 \\ a_1 \\ b_3 \\ b_4 \\ \vdots \\ a_1 \\ b_N \\ a_1 \end{bmatrix} \quad (18)$$

assume $\frac{b_j}{a_1} = \hat{b}_m$, where $m = 2,3,4,\dots,N$, then equation

(18) can be rearranged into

$$\begin{bmatrix} 0.5x_1^{(1)}(1) + 0.5x_1^{(1)}(2) \\ 0.5x_1^{(1)}(2) + 0.5x_1^{(1)}(3) \\ \vdots \\ 0.5x_1^{(1)}(n-1) + 0.5x_1^{(1)}(n) \end{bmatrix} = \begin{bmatrix} x_2^{(1)}(2) & \dots & x_N^{(1)}(2) \\ x_2^{(1)}(3) & \dots & x_N^{(1)}(3) \\ \vdots & \dots & \vdots \\ x_2^{(1)}(n) & \dots & x_N^{(1)}(n) \end{bmatrix} \begin{bmatrix} \hat{b}_2 \\ \hat{b}_3 \\ \hat{b}_4 \\ \vdots \\ \hat{b}_N \end{bmatrix} \quad (19)$$

3. Also use matrix method $\hat{B} = (Y^T Y)^{-1} Y^T X$ to solve the values of

$$\hat{b}_m \text{ where: } X = \begin{bmatrix} 0.5x_1^{(1)}(1) + 0.5x_1^{(1)}(2) \\ 0.5x_1^{(1)}(2) + 0.5x_1^{(1)}(3) \\ \vdots \\ 0.5x_1^{(1)}(n-1) + 0.5x_1^{(1)}(n) \end{bmatrix},$$

$$Y = \begin{bmatrix} x_2^{(1)}(2) & \dots & x_N^{(1)}(2) \\ x_2^{(1)}(3) & \dots & x_N^{(1)}(3) \\ \vdots & \dots & \vdots \\ x_2^{(1)}(n) & \dots & x_N^{(1)}(n) \end{bmatrix}, \hat{B} = \begin{bmatrix} \hat{b}_2 \\ \hat{b}_3 \\ \hat{b}_4 \\ \vdots \\ \hat{b}_N \end{bmatrix}$$

the relationship between the major sequence and the influencing sequences also can be found by comparing the value of \hat{b}_m .

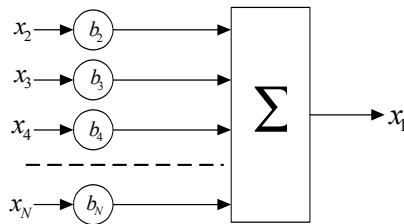


Figure 3. GM(0,N) model concept

IV. THE FACTOR ANALYSIS IN GAS BREAKDOWN

A. The influence factors

Based on the characteristics of our mathematics method, first, we selected four most important characteristics of the breakdown in gas, and decided the range of each characteristic by using the experimental method [13].

1. The ground surface potential gradient (∇V): From 0 kV/cm to 30 kV/cm.
2. The ratio of the ground surface potential gradient and time ($\frac{d\nabla V}{dt}$): From 0 kV/(cm·sec) to 10 kV/(cm·sec).
3. Atmospheric pressure: From 720 torr to 770 torr
4. Relative humidity: From 65 % to 85 %

B. Experimental steps

The whole steps are list below[8].

1. Set up the experiment equipments (photo 1).
2. Set up equipment capable of 30 sets, each set include 100 times testing (breakdown or not), totally 3,000 times (each time cost 5 to 10 minutes, hence, the total

experiment time is six mouths, and pass through summer, fall and winter three seasons).

3. Record all test data, and find its mean (TABLE I).

4. Take the data processing for each factor

- (1) ∇V : Large the better.
- (2) $\frac{d\nabla V}{dt}$: Large the better;
- (3). Atmospheric pressure: Nominal the better (76 cm-Hg).
- (4) Humidity: Large the better.
- (5) Error: Small the better.

TABLE I
THE EXPERIMENTAL DATA

No	G1	G2	G3	G4	G5	G6	G7
1	22.096	9.049	76.10	78.6	67	67.41	0.61
2	23.478	5.678	76.11	81.5	60	71.23	18.71
3	22.831	7.415	76.13	82.0	63	72.10	14.45
4	22.508	8.739	76.08	82.5	69	72.76	5.45
5	22.006	8.987	75.90	81.5	66	70.73	7.17
6	22.827	8.501	75.95	82.4	68	73.40	7.95
7	22.631	8.761	75.98	79.5	63	69.67	10.59
8	22.127	8.850	75.93	78.5	63	67.33	6.88
9	22.924	7.675	75.87	78.0	67	67.32	0.48
10	22.521	7.682	75.90	77.5	68	66.04	2.88
11	22.153	7.681	75.81	81.5	73	70.10	3.97
12	23.539	5.770	76.15	80.5	60	70.19	16.99
13	22.845	6.917	76.12	81.5	55	71.27	29.58
14	23.606	5.347	75.98	81.5	63	71.20	13.02
15	22.985	7.253	75.95	82.5	57	72.98	28.03
16	23.548	5.848	75.90	77.5	62	66.29	6.91
17	22.657	7.539	75.84	78.5	55	67.47	22.67
18	22.142	7.411	75.93	75.0	59	61.82	4.78
19	22.940	7.491	75.89	81.5	60	71.98	19.96
20	22.619	7.385	75.84	76.4	50	64.27	28.54
21	22.096	7.464	75.90	76.5	53	63.90	20.57
22	22.604	7.514	75.89	79.4	60	68.76	14.61
23	23.378	5.747	76.02	81.0	57	70.76	24.14
24	22.874	6.832	75.96	78.4	61	67.50	10.65
25	22.479	7.615	76.12	81.4	60	70.94	18.24
26	22.052	7.864	76.09	79.5	54	68.14	26.18
27	23.611	5.825	75.94	80.4	64	70.51	10.17
28	22.736	6.631	76.14	83.0	51	71.90	40.99
29	22.590	7.486	75.89	76.5	62	64.55	4.11
30	22.096	7.647	75.93	77.5	60	65.45	9.08

where: G1: ∇V . G2: $\frac{d\nabla V}{dt}$. G3: atmospheric pressure

G4: relative humidity. G5: experiment data.

G6: calculation data. G7: error.

C. Rough set method

1. Using Wu's globalization grey relational grade to find the simulation values of gas breakdown, and use traditional formula to find the error between the experimert value and simulation value, as shown in TABLE I[7].
2. The data will be selected for the ration, hence, in the red part will be omitted (error over 10%), and the results are listed in TABLE III (12 sets).
3. Using equal-gap discrete method (for four groups) to discrete the data, the results are shown in TABLE IV
4. Input the attribute factors $C = \{a_1, a_2, a_3, \dots, a_k\}$, and get the outputs.
5. Based on the mentioned above, we list the results in TABLE V.

TABLE II
THE SELECTED DATA

No	G1	G2	G3	G4	G7
1	22.096	9.049	761.0	78.6	0.61
2	23.478	5.678	761.1	81.5	18.71
3	22.831	7.415	761.3	82.0	14.45
4	22.508	8.739	760.8	82.5	5.45
5	22.006	8.987	759.0	81.5	7.17
6	22.827	8.501	759.5	82.4	7.95
7	22.631	8.761	759.8	79.5	10.59
8	22.127	8.850	759.3	78.5	6.88
9	22.924	7.675	758.7	78.0	0.48
10	22.521	7.682	759.0	77.5	2.88
11	22.153	7.681	758.1	81.5	3.97
12	23.539	5.770	761.5	80.5	16.99
13	22.845	6.917	761.2	81.5	29.58
14	23.606	5.347	759.8	81.5	13.02
15	22.985	7.253	759.5	82.5	28.03
16	23.548	5.848	759.0	77.5	6.91
17	22.657	7.539	758.4	78.5	22.67
18	22.142	7.411	759.3	75.0	4.78
19	22.940	7.491	758.9	81.5	19.96
20	22.619	7.385	758.4	76.4	28.54
21	22.096	7.464	759.0	76.5	20.57
22	22.604	7.514	758.9	79.4	14.61
23	23.378	5.747	760.2	81.0	24.14
24	22.874	6.832	759.6	78.4	10.65
25	22.479	7.615	761.2	81.4	18.24
26	22.052	7.864	760.9	79.5	26.18
27	23.611	5.825	759.4	80.4	10.17
28	22.736	6.631	761.4	83.0	40.99
29	22.590	7.486	758.9	76.5	4.11
30	22.096	7.647	759.3	77.5	9.08

TABLE III
THE DATA AFTER OMIT AND REARRANGE

No	G1	G2	G3	G4	G7
1	22.096	9.049	761.0	78.6	0.61
2	22.508	8.739	760.8	82.5	5.45
3	22.006	8.987	759.0	81.5	7.17
4	22.827	8.501	759.5	82.4	7.95
5	22.127	8.850	759.3	78.5	6.88
6	22.924	7.675	758.7	78.0	0.48
7	22.521	7.682	759.0	77.5	2.88
8	22.153	7.681	758.1	81.5	3.97
9	23.548	5.848	759.0	77.5	6.91
10	22.142	7.411	759.3	75.0	4.78
11	22.590	7.486	758.9	76.5	4.11
12	22.096	7.647	759.3	77.5	9.08

TABLE IV
EQUAL-GAP DISCRETE METHOD

No	G1	G2	G3	G4	G7
1	1	4	4	2	1
2	2	4	4	4	3
3	1	4	2	4	4
4	3	4	2	4	4
5	1	4	2	2	3
6	3	3	1	2	1
7	2	3	2	2	2
8	1	3	1	4	2
9	4	1	2	2	3
10	1	2	2	1	3
11	2	3	2	1	2
12	1	3	2	2	4

TABLE V
THE SIGNIFICANT VALUES IN SYSTEM

Factor	∇V	$\frac{d\nabla V}{dt}$	Atmospheric pressure	Relative humidity
Value	0.0083	0.4167	0.2500	0.1667

D. GM(h,N) method

Based on TABLE III, we let the influence factors $\{ \nabla V, \frac{d\nabla V}{dt}, \text{Atmospheric pressure, Humidity} \}$ are (x_2, x_3, x_4, x_5) , and the output is error (x_1) . Then by using equation (15) and equation (19), the weighting for each factor are shown in TABLE VI and TABLE VII.

TABLE V
THE RESULTS OF GM(1,N) MODEL

Factor	∇V	$\frac{d\nabla V}{dt}$	Atmospheric pressure	Relative humidity
$ b_j $	8.1413	2.8589	0.1771	0.9245

TABLE VI
THE RESULTS OF GM(0,N) MODEL

Factor	∇V	$\frac{d\nabla V}{dt}$	Atmospheric pressure	Relative humidity
$ b_j $	1.9653	0.7406	0.0222	0.3629

V. THE DEVELOPMENT OF TOOLBOX

In the toolbox, the input/output interface is based on *Matlab* GUI structure, and according to the characteristics of *Matlab*, the input data can expand into infinite to make this toolbox more powerful, no matter the rank is how huge, the operation processing will not be influenced[16]. The toolbox is based on Windows 2000 or upgrade version, and *Matlab* 2007 or upgrade version[17]. The whole operation steps are shown from Figure 4 to Figure 9.

VI. CONCLUSIONS AND DISCUSSION

In this paper, we proposed rough set and GM(h,N) method to deal with weighting problems under uncertainty environment. And an example of main influence factor problem in gas breakdown was used to illustrate the proposed approach. We have two interesting results, one is from rough set method, the most important influence factor is $\frac{d\nabla V}{dt}$ and ∇V in the minor factor, the reason is the number of grouping we select in four. However, the $\frac{d\nabla V}{dt}$ still is in group-I. The other is from GM(h,N) method, because the input data is original, we also find that $\frac{d\nabla V}{dt}$ and ∇V are in-group I, and relative humidity, atmospheric pressure are in-group II. The results means that our approach is quite reliable and reasonable, can apply in other relative field; this is the first contribution in our study. Also in the viewpoint of calculation, because *Matlab* have very convenient and practical software for engineering researchers, and its GUI function is a friendly interface. Hence, the rough set and GM(h,N) toolbox are created for our needs, this one is the second contribution in our study.

To sum up, we propose this new approach, which presented some contributions in power engineering and soft computing field. This study presents both theoretical and practical significance. However, the weak point still exists. Such as the different weighting analysis method and can extend the influence factors in the system.

Therefore, we suggest that we can combine other relative soft computing methods, such as fuzzy or GA with our study, and get more experiment data. Then, the research can be developed in future research.

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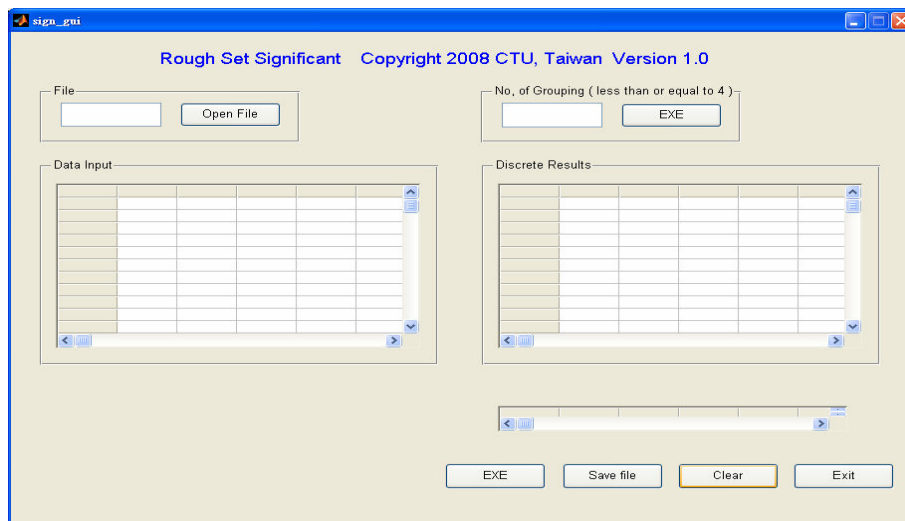


Figure 4. The main screen in rough set toolbox

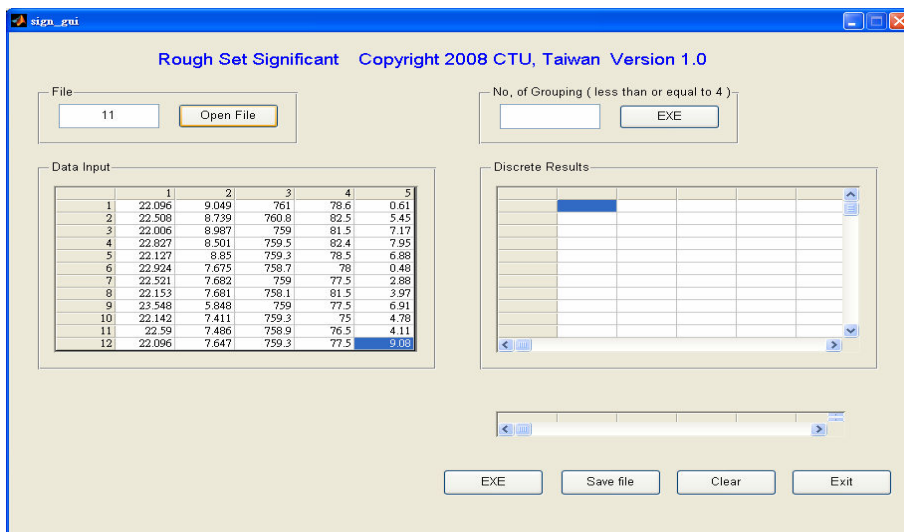


Figure 5. The original data input in significant model

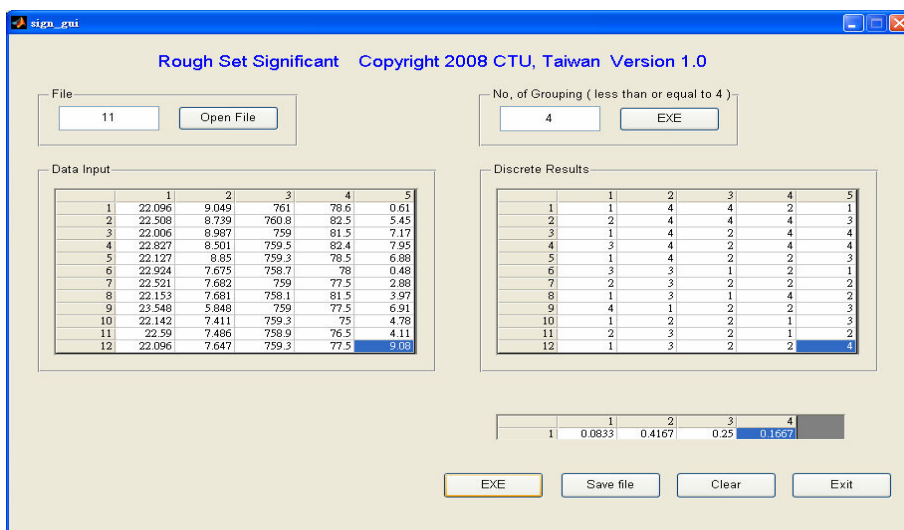


Figure 6. The results by using significant model

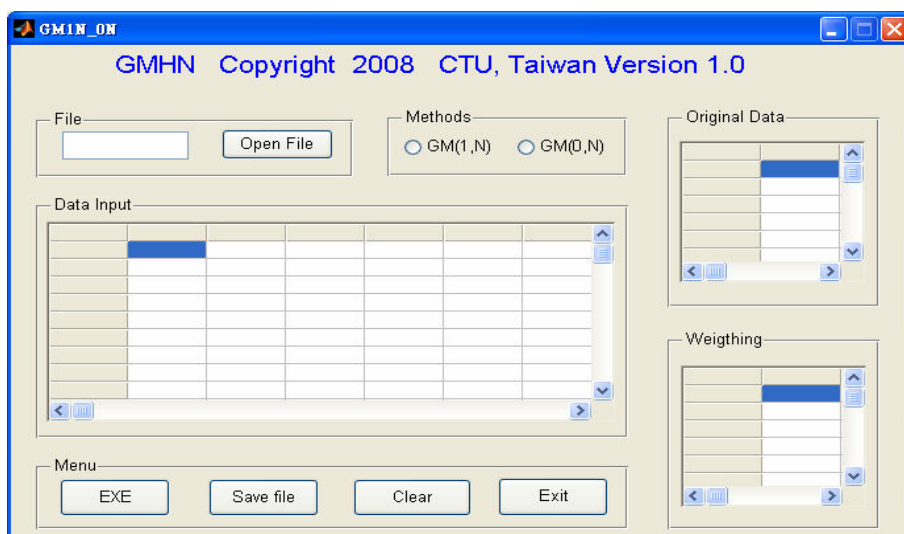


Figure 7. The main screen of GM(h,N) toolbox

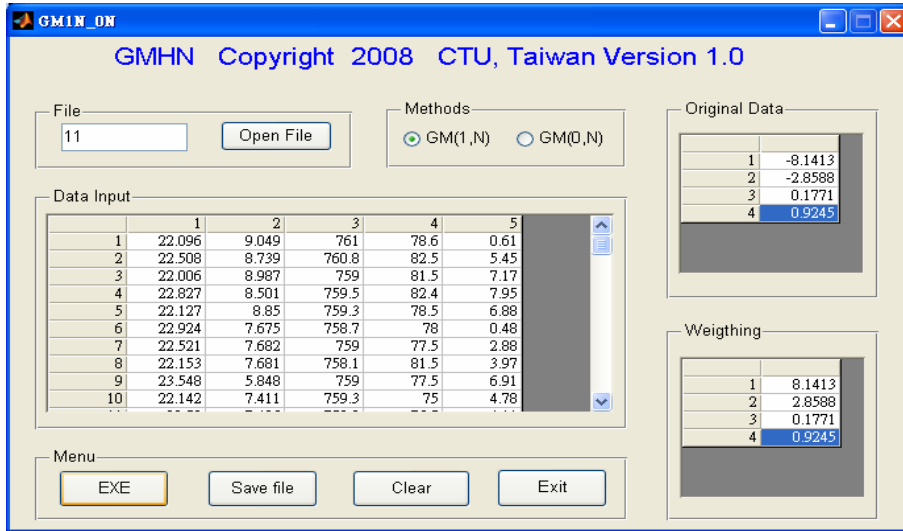


Figure 8. The results by using GM(1,N) model

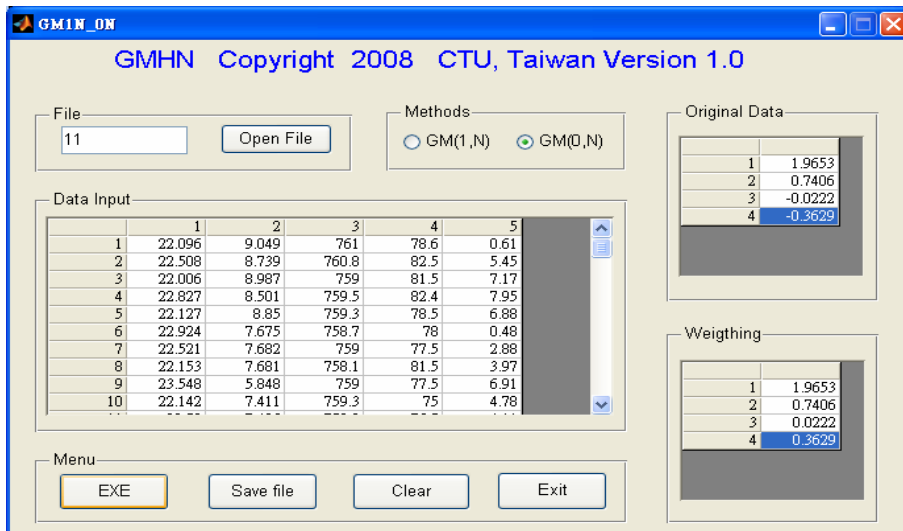


Figure 9. The results by using GM(0,N) model



Photo 1. The experiment equipments