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Research on a method of completeness index based on complex model

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Abstract

The completeness of the complex model is an important index to evaluate the pros and cons of the complex model. It is of great significance to study the objective evaluation under different indicators and construct an indicator system to ensure the integrity of the complex. The construction of complex system indicators requires instructors who can fully describe the functions of complex models. This study designs a complex index E_X , proves its authenticity through comparison with the real world, illustrates its similarity through conflict and comparison with the coverage of the target problem, and describes its intelligence level through confrontation and comparison with other complex models. Research on complex model problems based on the derivation process of domain theory proves that the quantified complete distance E_X can calculate the similarity between the model and the actual environment to evaluate 'true and false'. The experiment proved to be a reliable and complex model verification indicator.

Keywords: modelling method, index system, complex model, completeness index.

AMS 2010 codes: 76U05

1 Introduction

Research results related to completeness in the field of mathematics and physics. Under the condition of locally convex space, the completeness theorem of open mapping can be expressed as when the domain space E is entirely complete, the continuous almost open linear mapping from the locally convex space to the locally convex space is an available mapping [1]. At the same time, when the continuous almost open linear mapping from the locally convex space E to any locally convex space is always an available mapping, the domain E is entirely complete [2].

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2 Research on completeness issues

In a knowledge expression system [3], Information System S can be expressed as a two-tuple, $S = (U, AT)$. Among them, U represents a non-empty finite set of objects, called the universe of discourse; AT means the collection of all attributes $\forall a \in AT$, V_a means attributes a 's range, $a(x) \in V_a (\forall x \in U)$. Here $a(x)$ represents the value of the object x on the attribute a . In the information system S , if $\exists a \in U$. The value of x attribute $a(a \in AT)$ is unknown. The information system S is called an incomplete information system, otherwise it becomes a complete information system [4].

In the completeness calculation method of the modelling field, the researcher uses the bottom event weight analysis method to complete the completeness calculation of the emergency plan based on the Bayesian Network [5]. By calculating the weight of each basic event in the standard Bayesian network, that is, the degree of influence of the event on the top event, the proof of all nodes is completed, thereby completing the complete calculation [6]. For non-discrete problems, it is possible to expand multiple levels with explanatory relations, analyse and make decisions at the target level according to the pros and cons of decision indicators and convert difficult-to-assign comparison relations into mathematical methods for calculations to complete system decision-making—completeness calculation.

In this study, the expression of the target problem is set, and it is verified that the parameter set of the target problem can construct the locally convex space E , and complete the continuous almost open linear mapping from the locally convex space E to the locally convex space. It is an open mapping, and then you can prove the completeness of the target problem P_s and model construction.

3 Complete modelling technology

There is no research on the general expression method of modelling completeness in the simulation field. Usually, based on specific tasks and typical scenarios, the completion of the target task, the fidelity of the simulation system and the similarity of the results between different systems are used as the basis for judging the completeness of the system. Researchers have proposed a series of specific completeness methods. For example, for the damage effect simulation degree index, there are studies on the electromagnetic echo change after consistent deduction so as to find the weak point of the equipment model entropy. This indirect evaluation method is an effective system simulation degree evaluation technology [7]. At the same time, some researchers have proposed a method of spectrum comparison to verify the simulation results. Aiming at the comparison of the similarity of multiple sets of similar data, the researcher proposed a direct comparison method to evaluate the similarity of the two sets of data. By comparing the similarity of energy parameters, the amplitude, The weight of the, and the weight of the frequency spectrum, so as to complete the comparison process of the similarity between the simulated data and the measured data.

In addition, researchers extract different types of environmental information through the feature selection test method and use the numerical change method to amplify the feature differences so as to evaluate the indicators that are not obviously quantified. The specific process of this method is shown in Figure 1. The verification results of various levels of differences can be calculated. The specific evaluation method is to collect the calculated data and measured data of the model and use the difference calculation method to separate the elements such as amplitude and frequency. The separation values are compared in turn, and the global difference estimate is finally obtained. The similarity grading template is used to complete the similarity grading evaluation process.

In the comparison between the real environment and the simulation system, the US Air Force Research Office has been conducting research. The organisation layer proposes a uniform matching coefficient to measure the similarity of the measured and predicted images [8]. The National University of Defense Technology has also used this method to compare the simulated and measured SAR images of a military unit and set a specific distance for the uniformity matching index. The advantage of this method is to use the uniformity matching sparse index to calculate the quality description and credibility description of the single point of the image. At

the same time, the index is versatile and can be compared with the results of expert visual evaluation.

Fig. 1 The similarity evaluation block diagram of the feature selection test method.

These methods are relatively complete in terms of indicators and can support the verification of the completeness of modelling under specific businesses. Facing the more general intelligent blue square modelling, a complete distance method and error characterisation form are constructed, as much as possible to ensure the completeness of the intelligent blue model in the modelling process.

4 Deduction principle of completeness of the complex model

The introduction section explores the completeness of the proof process. At the same time, in the complex model principle, the basic principle of the complex model target problem is explained in symbolic form. is the general form of the target problem, $P_t = \{X_t, C_t, F_t\}$ is the general form of the target problem and $P_T = P_{t1}^\theta + P_{t2}^\theta + \dots + P_{tn}^\theta$. That is, the target problem can be decomposed into several target problems to be solved. When P_T is a complex problem that cannot be solved currently by dividing P_T into solvable polynomial parts $\{P_{t1} + \dots + P_{tn}\}$, then the problem to be solved is P_{tn}^θ . At the same time, the input function is mapped to $\{X_{t1} + \dots + X_{tn}\}$, the knowledge function is mapped to $\{C_{t1} + \dots + C_{tn}\}$ and the evaluation function is mapped to $\{F_{t1} + \dots + F_{tn}\}$.

From the perspective of domain theory, $S = P, AT, P_t = \{X_t, C_t, F_t\}$, where S is the complex model space, P is the complex model problem space, AT is the solution domain and P_t is the blue square. The problem is to obtain the value of P_t in space if $\exists P_t \in P$. If $A_t \in AT$, that is, the blue problem P_t is a solvable problem, then the blue problem P_t is complete. If $\nexists A_t \in AT$ then the blue problem P_t is an unsolvable problem, and the blue problem P_t is not complete.

Therefore, when P_T is complete, its polynomial form of $P_{t1} + \dots + P_{tn} \dots$ and all subproblems are complete, and its variable parameter functions X_T, C_T, F_T , are all complete. When P_T is incomplete, it can be written that its $\{\dots\}$ part is complete, and the problem to be solved P_{tn}^θ is incomplete.

The complexity of the game problem, i.e., the type of problem, is called a complex blue square problem, also known as a complex domain problem. When the complex model problem P_T is an incomplete problem, at least one of X_T, C_T, F_T , is an incomplete parameter function.

Suppose there is a correct solution $A_t = \{X_{at}, C_{at}, F_{at}\}$ in the complex model space, and there is a process from the complexity problem P_t to the correct solution A_t , then $X_t + E_X = X_{at}, C_t + E_C = C_{at}, F_t + E_F = F_{at}, P_T + E_P = A_t$.

It can be obtained that is the complete distance of the input function X_t, C_E is the complete distance of the constraint function, C_t is the complete distance of the calculation function F_t and E_P is the complete distance of the target solution A_t .

5 Modelling method of complete distance E_X

5.1 The physical meaning of the complete distance E_X

The complete distance E_X is the target solution parameter function X_{at} and the current solution parameter function X_t . Therefore, from the perspective of physical meaning, E_X is mostly caused by the difference in data from the real world to the model, and this difference is often very obvious.

Taking the actual problem of crowd movement as an example, measuring crowd pressure is the main task of the social emergency system. Crowd pressure is determined by crowd flow rate. It uses crowd movement presentation media as input for multi-source information, physical modelling of roads and road use. The ratio of the width to the number of recognised people is used as the basic characteristic of the crowd flow rate so as to determine the current road crowd pressure characteristics and possible emergency challenges, as shown in formula (1).

$$Challenge(T) = \frac{F(Crowd, T)}{F(Width)} \quad (1)$$

However, the real crowd is composed of participants with height and weight, and they are affected by personal movement characteristics during the actual exercise. This is quite different from the motion model that is simply abstracted as a mass point during the simulation environment and simulation object based on the mass point. Once the logic model is formed, it is difficult for the system to improve its fidelity. This is a self-constraint, which is determined by the self-closed loop characteristics of the information source, simulation environment and simulation object as shown in formula (2).

$$Challenge(T) = \sum_i^T \frac{F(Person_i, State(Person_i))}{F(Width)} \quad (2)$$

This process of abstracting from the prototype system of the real environment to the typical simulation system based on the mass point has produced cumulative errors, although some researchers try to use complete context logic, rich constraint functions and more detailed simulation object structures. There is an improvement, but this error still exists, that is, E_X has to be calculated.

5.2 Calculation of the complete distance E_X

Since X_{at} is difficult to obtain and describe in practical problems, such as the actual size of an object, X_t can be obtained through a series of measurement and acquisition methods, but E_X at this time cannot be directly calculated.

The algorithm sets a transfer function $X_{at} \in x$, $X_t \in x$, and its inverse function $F(x)$, then the calculation formula $\overline{X_E}$ (3) can be obtained indirectly.

$$\overline{X_E} = F(f(X_{at})) - F(f(X_t)) \quad (3)$$

5.3 The calculation process of $\overline{E_X}$ in the track simulation

For E_{at} , the physical meaning in the real world is clear. For the same problem, the results are obtained by observing the real world and the simulation model, but the physical meaning is not limited to this. Take the observation orbit data and system as an example to calculate $\overline{E_{at}}$.

Obtain the trajectory of the output elements in the t time interval in the simulation system synchronised with the orbital running time interval of S_i to derive the simulation data SEA and the three-dimensional space coordinates of the two static objects corresponding to each keyframe of S_i , and use the distance formula between the two points to calculate the output distances R_1 and R_2 of the output elements and two static objects in each key frame of S_i and the spatial distances S_1 and S_2 in the t time interval in the simulation system. According

to a certain distance ratio verification condition, the simulation data and output elements are correspondingly compared data.

Define $R_1 : S_1$ as a_1 and $R_2 : S_2$ as a_2 , then in the synchronisation environment, time interval $t = \{t_1, t_2, \dots, t_m\}$ there are $\{a_{1t}\}$ and $\{a_{2t}\}$, where $\{a_{1t}\}$ has the form (4), $\{a_{2t}\}$ has the form (5).

$$\{a_{1t} | R_{1t} : S_{1t} = a_{1t}\} \quad (4)$$

$$\{a_{2t} | R_{2t} : S_{2t} = a_{2t}\} \quad (5)$$

If the effects of *REA* and *SEA* in the simulation system are the same in the orbital time interval of S_i , the ratios of $\{a_{1t}\}$ and $\{a_{2t}\}$ in the orbital time interval $t = \{t_1, t_2, \dots, t_m\}$ are equal, as shown in Figure 1.

The ratio between $\{a_{1t}\}$ and $\{a_{2t}\}$ at a specific moment is not equal to other moments. There is an error between the real spatial position of the output element at that moment and the simulation data in the simulation system, so that in the trajectory and simulation of the output element within the orbital time interval, there are errors in the data.

Ideally, if there is no error in the simulation deduction of the output element characterisation state, that is, the effects of *RPA* and *SPA* are the same, and the respective ratios of $\{a_{1t}\}$ and $\{a_{2t}\}$ are equal. The respective ratios of $\{a_{1t}\}$ and $\{a_{2t}\}$ are evaluated as r_1 and r_2 $\overline{E_{at}}$, reference value, at this time $r_1=r_2=1$, $\overline{E_{at}}$ is 0. If the ratio of $\{a_{1t}\}$ and $\{a_{2t}\}$ at a certain time is not equal to other time, define the ratio of $\{a_{1t}\}$ and $\{a_{2t}\}$ at that time to the ratio of other time as r_{1t} and r_{2t} and the ratio r_t of r_{1t} and r_{2t} is the time $1-\overline{E_{at}}$.

The simulation model is constructed and compared with the actual performance results, the presentation process of the output elements is simulated, and the presentation process of the target problem is recorded at the same time.

In this research, a simulation system and peripheral components capable of observing environmental changes are constructed. It can model and store the physical characteristics, position and trajectory parameters of the scene environment. The control simulation of the system can obtain the physical trajectory and output simulation data.

The simulation model relies on the characteristics of the elements established by the simulation pipeline to simulate the characterisation state of the elements. For example, in the visualisation system, such as colour, position, volume characterisation, the continuous performance of the element characterisation at different times is selected. The characterisation state and vector characteristics in the trajectory running time interval.

Fig. 2 The calculation process of $\overline{E_X}$ in the track simulation.

According to the interpolation process at the continuous time, the characterisation process of the element is constructed, in which the three-dimensional space coordinates and vector characteristics of the entity element in the complex environment at a specific time t are shown in formula (6).

$$sea_{it} (x_{it}, y_{it}, z_{it}, rx_{it}, ry_{it}, rz_{it}) \quad (6)$$

At this time, the set of three-dimensional space coordinates and vector features of all entity elements $i=\{1, 2, 3, \dots, n\}$ is shown in formula (7).

$$SEA_t = \{sea_{1t}, sea_{2t}, \dots, sea_{it}, \dots, sea_{nt}\} \quad (7)$$

In the running time interval $t = \{t_1, t_2, t_3, \dots, t_m\}$ of the entity elements in a period of time, the representation state position data set SEA of all the entity elements entity t travelling along the trajectory is given as in formula (8).

$$SEA = \{SEA_{t_1}, SEA_{t_2}, SEA_{t_3}, \dots, SEA_{t_m}\} \quad (8)$$

In the data acquisition stage, by comparing the simulation data with the real source orbit data obtained by processing the imaging presentation media captured by the presentation media monitoring, it is determined that the data modelling corresponding to the simulation is required.

In the data comparison stage, the two-dimensional position coordinates of a single entity element rea defined at a specific time t on the medium orbit are $rea_{it}(x_{it}, y_{it})$ and the two-dimensional position coordinate set REA of all entities presents the key to the medium. The data $i = \{1, 2, 3, \dots, n\}$ in the frame is shown in formula (9).

$$REA_t = \{rea_{1t}, rea_{2t}, \dots, rea_{it}, \dots, rea_{nt}\} \quad (9)$$

In the orbit time period $t = \{t_1, t_2, t_3, \dots, t_m\}$, when all the physical elements i are running along the orbit, the representation state position data set REA in the key frame sequence of the presentation medium is expressed by formula (10).

$$REA = \{REA_{t_1}, REA_{t_2}, REA_{t_3}, \dots, REA_{t_m}\} \quad (10)$$

In the calculation stage, the position of the simulated entity group is compared with the position of the characterising entity group, and the formalisation of $\overline{E}_{at}$ is obtained, as shown in formula (11).

$$\overline{X}_E = \frac{1}{t_m - t_1} \sum_{i=t_1}^{t_m} \frac{REA_{t_i}}{SEA_{t_i}} \quad (11)$$

6 Verification of the completeness method of the complex model

The actual problem trajectory tracking and simulation process involve a huge multi-source data fusion process, which has the characteristics of huge calculation data volume, relatively fuzzy evaluation results and unclear end points of the problem. Continuous improvement of evaluation methods in the simulation process has the characteristics of fuzzy calculation boundaries. It is a typical complex practical problem, which is used as an experimental environment. Compared with the image comparison task, the Go game task is relatively simple in the data source, but the evaluation of the comparison result of the mid-game is very vague, and its game behaviour is sequential and continuous, and the learning data cited is diverse, so in Go, the disc task has the characteristics of fuzzy computing boundaries and unclear endpoints. It is also a small atypical game problem. In this section, multiple sets of scenario experiments will be used to apply the complete distance calculation process. Including the incomplete verification of the difference between the distance E_X based on nine-way Go, the incomplete verification of the difference between the image and the image of E_X , the test based on the blue square component constraint merge distance E_c of the multi-granularity model, and the general search algorithm based on the complex model algorithm set, complete the comparison and calculation of the evaluation function between the algorithms of the structure.

6.1 The purpose of the experiment

The actual problem trajectory tracking and simulation process is a typical complex actual problem. Use this as an experimental environment to verify the effect of the completeness distance on actual problems. The video

Table 1 Model P_1 and model P_2 completeness distance index E_X experimental information table

Experimental parameters	Condition example
Testing purposes	The performance of the blue square model P_1 and the blue square model P_2 in different mid-markets, and its completeness distance index E_X
Test function	$\overline{X}_E = \frac{1}{t_m - t_1} \sum_{i=t_1}^{t_m} \frac{REA_{t_i}}{SEA_{t_i}}$
Test environment	Random Go, Windows7, VS2010
Contrast variable	$F_{0-4}(200)$, $F_{5-9}(200)$, $F_{10-14}(200)$, $F_{15-19}(200)$ and $F_{20-24}(200)$
Data set	A complete game record of 2500 nine-way Go in the StoneBase game record
Data instance

data of the real orbit system and the simulation vector data of the virtual simulation system are input into the complex model, and the completeness distance E_X is used to describe the difference between the two systems, thus proving the effectiveness of E_X in describing the fidelity of the system.

6.2 Experimental method

This experiment studies the completeness of the target problem of the complex model using domain theory to prove several conditions for the completeness of the complex model, one of which is the expression of the distance E_X caused by the difference of the data; the distance can be passed through the transfer function $f(x)$, which indirectly calculates the complete distance between simulation systems and can also test the morphological difference between the real environment and the simulation system, which can be used in the selection process of knowledge and the improvement process of the cognitive network model.

6.3 Experimental process

This experiment constructs the first set of experimental Table 1 to test the performance of the blue square model P_1 and the blue square model P_2 in different mid-markets and its completeness distance index E_X .

The experiment uses the Random Go nine-way Go system to compare the distance E_X between the complex model models P_1 and P_2 . The blue model P_1 uses UCT and Monte Carlo algorithm for knowledge selection, and the blue model P_2 uses a 3×3 pattern recognition move algorithm for knowledge selection. At the same time, select the static game record of StoneBase 1000 mid-games for the distance E_X constraint comparison process, including the opening scenes $F_{0-4}(200)$, $F_{5-9}(200)$, $F_{10-14}(200)$, $F_{15-19}(200)$ and $F_{20-24}(200)$, etc. The difference of the completeness distance index under different middle game steps.

This experiment constructs the second set of experimental Tables 2 Test track simulation and observation system distance E_X , in the state of continuous 300 frames, the consistency of the movement of each entity. The study uses orbit simulation and observation system observation distance E_X to compare the distance E_X between the simulation system and the real world. This target problem uses the observation module to obtain the current

state information in the vision and compares the actual simulation information of the simulation system to obtain the incomplete target distance.

Table 2 Orbit simulation and observation system observation distance E_X experimental information table

Experimental parameters	Condition example
Testing purposes	Orbit simulation and observation system observation distance E_X , in the state of continuous 300 frames, the consistency of the motion of each entity
Test function	$\overline{X}_E = \frac{1}{t_m - t_1} \sum_{i=t_1}^{t_m} \frac{REA_{t_i}}{SEA_{t_i}}$
Test environment	Random Go, Windows7, VS2010
Contrast variable	Frame 100, 200, 250, 275
Data set	A track simulation system
Data instance

This experiment constructs the third set of experimental Table 3 using the complex model cognitive network to generate video and real video for observation distance E_X . The research uses a cognitive network to generate video and real video to observe the distance E_X , and observe the completeness of the generated video target from the perspective of key feature tracking.

Table 3 Experimental information table of the relationship between generated knowledge and generated video

Experimental parameters	Condition example
Testing purposes	Use the complex model cognitive network to generate video and real video for observation distance E_X
Test function	$\overline{X}_E = \frac{1}{t_m - t_1} \sum_{i=t_1}^{t_m} \frac{REA_{t_i}}{SEA_{t_i}}$
Test environment	TensorFlow, Cuda, Windows7, VS2010
Contrast variable	Frame 100, 200, 250, 275
Data set	600 video framed images of the Cityscape dataset
Data instance

6.4 Experimental results and analysis

The experimental result in Table 4 shows that the placement order of the model is inconsistent with the placement order of StoneBase. This inconsistency is one of the characteristics of the difference between the learning network and the natural person. However, as the number of moves increases, the completeness of the distance keeps E_X shrinking. This shows that facing the placement process of the middle board of Go, the complex model and the cognition of natural persons gradually converge, indicating the effectiveness of the value evaluation function.

Table 4 Table of experimental results of completeness distance index for E_X model and P_1 model

E_X	$F_{0-4}(200)$	$F_{5-9}(200)$	$F_{10-14}(200)$	$F_{15-19}(200)$	$F_{20-24}(200)$
P_1	0.72	0.28	0.23	0.18	0.13
P_2	0.83	0.18	0.14	0.12	0.06

In addition, it is found that the algorithm based on pattern matching is more random when there are a few moves, that is, the distance E_X of P_2 is much larger than P_1 , and as the moves increase, the stability of the distance E_X increases, indicating that the pattern structure is good. In the case of dense chess pieces, it is easier to match the pattern. The experiment also shows that the completeness distance E_X can effectively discover the differences between the models and lay the foundation for the improvement of the models.

Experimental results in Tables 5 and 6 are the synchronisation position gap between a certain track system simulation data and video acquisition data. Through the data, it can be found that the completeness distance difference of different entities is different. The value X_E for each entity that does not exceed 1% is relatively stable, which shows that the system simulation process has high completeness. From another perspective, the distance X_E may be caused by the error of the lens shake, the optical effect of the collecting lens and the signal noise. This shows that any complete system is a high degree of coordination between software and hardware, and neither is indispensable.

Table 5 Track system entity simulation two-dimensional position coordinate experiment result table

Entity	Frame 100	Frame 200	Frame 250	Frame 275
1	(377, 241)	(280, 283)	(296, 317)	(329, 329)
2	(386, 241)	(288, 284)	(313, 317)	(346, 323)
3	(401, 239)	(297, 286)	(322, 322)	(369, 326)

Table 6 Experimental result table of physical pixel distance of track system

Entity	Frame 100	Frame 200	Frame 250	Frame 275
1	400, 696	505, 801	510, 795	490, 768
2	392, 688	498, 793	496, 779	473, 750
3	379, 673	492, 785	491, 772	457, 729

Table 7 The completeness distance index E_X experiment result table of track system simulation and acquisition source

Entity	Frame 100	Frame 200	Frame 250	Frame 275
1	0.1562	0.1587	0.1546	0.1565
2	0.1495	0.1492	0.1457	0.1684
3	0.1874	0.1854	0.1871	0.1824

Table of experimental results 7. Figure of experimental results 5.1 The observation distance E_X between the complex model cognitive network generated video and the real video. This experiment uses 600 video framed images of the Cityscape dataset to generate three sets of generated data up to 300 frames.

From the overall effect of distance E_X , the average E_X value of the video generated by the cognitive network does not exceed 2.1%, where Create_1 is the average E_X value of the video generated when the 100th frame is held, Create_2 is the average E_X value of the video generated when the 200th frame is held, Create_3 is the average E_X value of the generated video when the 250th frame is maintained and Create_4 is the average E_X value of the generated video when the 275th frame is maintained. At a lower completeness distance, it indicates that the generated data is successful.

The experiment shows that as time increases, the distance E_X index of the three sets of data increases, and the two show a positive proportional relationship. This represents an increase in the difference between the generated data and the original data and also represents the creativity of the cognitive network. Experiments show that the generated data 3 greatly increases in the distance E_X , which is caused by the generation of bad data. It also proves that the cognitive network still needs someone to participate and guide. These experiments all prove that the distance E_X is an accurate completeness index.

Fig. 3 The completeness distance index result between the generated data and the original data.

7 Conclusion

Two sets of experiments show that E_X fully characterises the static difference between systems and the time-based dynamic difference. Using the completeness calculation of E_X can effectively evaluate the differ-

ence between systems, especially the fidelity of virtual systems in real environments. From the overall effect of distance E_X , the average value of video E_X generated by the cognitive network does not exceed 2.1% in conclusion.

This paper studies the completeness problems faced by complex models and defines the completeness index and its physical meaning through the study of the definition of the target problem. At the same time, the study derives the calculation process for each indicator. These indicators reflect the intelligence, complexity and completeness characteristics of the complex model from different sides. At the same time, the effectiveness of these indicators is tested by using Go information and image information data. Among them, the complex model clarifies its fidelity through E_X confrontation and comparison with the real world, clarifies its similarity through E_c confrontation and comparison with target problem coverage and clarifies its intelligence level through E_F confrontation and comparison with other complex models. Specific experiments prove that the E_X indicator is effective, and its stability is relatively high in the face of practical problems, and the fluctuation does not exceed 1%. The E_c index effectively indicates the matching and decomposition process of constraint conditions >1,000 scales and has reliability. The E_F indicator correctly indicates the difference in the winning rate of different algorithm models and is reliable.

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