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Retraction

Retracted: Attribute Reduction Algorithm on Concept Lattice and Application in Smart City Energy Consumption Analysis

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] C. Wang, Y. Bo, and C. Xu, "Attribute Reduction Algorithm on Concept Lattice and Application in Smart City Energy Consumption Analysis," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 8961683, 12 pages, 2022.

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Research Article

Attribute Reduction Algorithm on Concept Lattice and Application in Smart City Energy Consumption Analysis

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With the economic development in recent years, smart cities have also risen. Smart city is based on the next generation of innovation in the knowledge society, and the use of new generation information technology in all areas of the city is conducive to the improvement of the quality of urbanization and the quality of citizens' lives. This article aims to study the significance of the reduction algorithm in the energy consumption analysis of smart cities. This article puts forward the problem of how to solve the problem of huge energy consumption in smart cities. In smart cities, the related objects that generate energy consumption mainly include industry, agriculture, and transportation construction. People's lives are ubiquitous in the generation of energy consumption. This paper analyzes the energy consumption of smart cities through the reduction algorithm and puts forward a plan on how to reduce the energy consumption of smart cities, which is meaningful for the rational use of resources and reducing the cost of smart cities.

1. Introduction

At present, the city is facing a number of problems from economic, social, and environmental aspects in its continuous development process. The main reason is that cities have not yet formed strong sustainable development capabilities and the development concept of smart cities is to strengthen the city's self-regulation through ubiquitous perception. Therefore, countries have successively begun to explore the construction of smart cities, have gradually been recognized by the public, and finally become an important trend in the development of urban construction. At present, the construction of global "smart cities" is still in the process of exploration, and the connotation of smart cities is constantly deriving and changing. Smart energy is an important cornerstone of smart city construction. With the advancement of smart city construction, the economic benefits of energy conservation and emission reduction through "smart energy" will occupy an increasingly important position.

The central idea of the smart city concept is to use computer technology to improve the competitiveness of the city. With the rapid development of Internet technology, especially in recent years, with the development of mobile Internet technology, data support has been provided for urban construction. At the same time, extensive statistics are conducted on the energy consumption of large-scale public buildings in China, and the lack of scientific energy consumption monitoring and prediction has seriously hindered the development of energy-saving work in large-scale public buildings. Therefore, research on energy consumption prediction and monitoring systems for large-scale public buildings is particularly important.

With the construction of smart cities, the future development of cities mainly depends on ubiquitous sensing and information that can be accessed and controlled at any time. Wu found that since the reform and opening up, the problem of energy consumption has become more and more serious, restricting the management and development of the city. In recent years, smart cities have been proposed as an effective way to achieve better city management. Smart cities aim to closely integrate human wisdom and information and communication technologies and ultimately can establish information links and synergy through cloud computing and other information and communication technologies. However, in China, few studies have systematically linked smart cities with big data. Therefore, it is necessary to plan urban infrastructure reasonably [1]. Menouar found that without a reliable and efficient transportation system, there would be no smart city. This necessity makes ITS a key component of any smart city concept. Although traditional ITS technology has been deployed in smart cities on a global scale, the implementation of next-generation ITS relies on the effective integration of connected cars and autonomous vehicles, and it is undergoing extensive field testing in many cities around the world. He described possible ITS applications that can use drones and emphasized the potential and challenges of ITS that support drones in the next generation of smart cities [2]. Daniel found that technological advancements in multiple fields have promoted the development of smart city applications, which can improve the lifestyle of modern cities. When using a visual sensor in this case, still images and video can be retrieved from the monitored area, which may provide valuable data for many applications. He proposed a method that can be regarded as the basis of multisystem smart city applications based on visual surveillance, which is expected to bring significant results to the research field of smart cities [3]. Bates demonstrated the use of existing IoT infrastructure to create campus-scale "living laboratories" to promote energy conservation and environmental sustainability. From a purely data-driven perspective, it emphasizes the limitations of a specific view of the campus and advocates a data-driven approach to data perception rather than interaction with various stakeholders. Finally, he reflected on people's practice in understanding and designing smart cities, reusing the existing Internet of Things [4]. Valdez found that the concept of smart city is ubiquitous in the discourse of urban development. Various frameworks for smart city development are usually conceptualized as a roadmap, which puts forward some implicit propositions on how smart city projects should proceed, but the legitimacy of these propositions is unclear. He began to address this knowledge gap and explored the development of smart transportation applications in the context of the 16 million smart city plan. He studied how idealized smart city narratives are affected locally. Research shows that the data-driven efficiency vision outlined in the roadmap is not universally convincing and different urban flow perception and optimization methods have the potential to enhance or weaken different participants [5]. Massana believes that if the city is to be sustainable, smart cities should be used, and a variety of services should be developed. He proposed a classic data-driven building load forecasting model, which can alleviate the burden of huge data and excessive pressure on smart cities. But he did not mention how to reduce the burden [6]. Yeh found that information and communication technology can promote the connection and cooperation between government enterprises. The new innovative concept of smart city will also improve the efficiency of serving people and improve people's quality of life and beautiful urban environment. But he did not mention the purpose of his research [7]. Jordi found that the relationship between smart cities and computer technology is very close and computer technology can promote the development of smart cities. He proposed the use of wireless technology to solve problems in smart cities. But no specific solution is mentioned [8]. Through the experiments and analysis of scholars, it can be known that smart cities develop with the development of social economy. Nowadays, there are more and more smart cities, and people pay a lot of attention to smart cities, but the energy consumption of smart cities is also very high. However, the experiments of scholars lack variables and new methods, so it is very important to find new methods.

The innovations of this article are as follows: (1) introduced the reduction algorithm and the related theoretical knowledge of smart cities and used the association algorithm based on data mining to analyze how the integration of the reduction algorithm and data mining to study the energy consumption of smart cities. (2) Based on the association algorithm of data mining and the reduction algorithm, the experiment and analysis of the energy consumption research of smart cities are carried out. Through investigation and analysis, it is found that the energy consumption generated by smart cities can be reduced through the Internet of Things.

2. Reduction Algorithm Based on Rough Set and Association Algorithm Based on Data Mining

The development of today's cities is facing many problems, and a solution must be sought. Since advocating the concept of smart city, countries around the world have increased the pace of smart city construction, and Chinese cities have also actively responded and have continuously introduced various planning measures for smart city construction [9]. Judging from the current situation, the development process of Chinese smart cities does not deviate from the previous construction models and mechanisms, and there are still many problems and risks in the construction process. This is due to the fact that the development of smart cities is still in its infancy and lack of relevant theoretical research and practical experience. In this context, it is of great significance to study the related theories of smart city energy consumption [10]. Concept lattices are considered a powerful tool for data analysis. The process of generating concept lattices from a data set (called formal context in concept lattices) is essentially a concept clustering process; however, concept lattices can be used for many machine learning tasks. At present, there have been some algorithms for constructing concept lattices, and concept lattices have been applied in information retrieval, digital library, software engineering, and knowledge discovery. The application areas of smart cities are shown in Figure 1.

As shown in Figure 1, on the basis of policy support and complete infrastructure, the application scenarios of smart cities are increasingly enriched, such as smart security, smart transportation, smart communities, smart commerce, smart tourism, smart environmental protection, and smart energy.

Although the construction and development of smart cities are still being explored, and the construction mechanism is not sound, the ability of smart cities to quickly, flexibly, and accurately understand and solve various activities that have been recognized by people [11].

2.1. Reduction Algorithm Based on Rough Set Theory. The reduction problem based on rough set theory is an important research content of machine learning, and it is also a very difficult and meaningful topic in machine learning and pattern recognition [12]. Rough set theory is a new mathematical tool used to deal with uncertain and incomplete systems. At present, the more frequently used method is inductive learning. Scholars have done a lot of research on the rule acquisition related to rough set theory, but there are still shortcomings in terms of spatiotemporal performance and completeness [13].

Concept lattice is the process of generating concepts from the concepts in the data set, which is essentially a process of concept clustering. Concept clustering is a very important norm and technique in machine inductive learning research. Inductive learning is actually a kind of multiconcept learning, which is a reasoning process from special to general, from individual to common, and from specific to general. The concept lattice structure is shown in Figure 2.

As shown in Figure 2, the graphical representation of the concept lattice is an effective way to spread knowledge and establish a high level of transparency. Various connections and interpretations of knowledge can be visualized through Hass diagrams of various concept lattices. The Hass diagram of the concept lattice is generated according to this partial order relation of the concept lattice [14].

2.1.1. Concept Lattice Reduction Algorithm Based on Discernibility Matrix. First of all, this article introduces the related theory and knowledge of conceptual grid reduction based on the identifiable matrix and introduces its design and implementation. Difference matrix, also known as identifiable matrix or distinct matrix, is a method of representing knowledge, which has the advantage of being able to explain and facilitate the computation of data kernels and reductions.

Suppose that DIS_{FC} is the formal background, and $B_I \cup B_J$ difference attribute set is

$$DIS_{FC}(A_1, B_1), \left(A_J, B_J\right) = B_I \cup B_J. \tag{1}$$

Unifying the set of non-empty elements is also recorded as A_{FC}, that is,

$$A_{FC} = \left\{DIS_{FC}(A_1, B_1) \middle| \left(A_j, Bj\right)\right\} A_{FC} = \left\{DIS_{FC}(A_1, B_1) \middle| \left(A_j, Bj\right)\right\}. \tag{2}$$

The reduction to find the formal background is actually to find the minimum attribute set H that satisfies the condition $DIS_{FC}(A_1, B_1)$.

Suppose that (U, A, I) is the formal background, and its difference function is

$$\varphi(A_{FC}) = H \wedge A_{FC}. \tag{3}$$

The concept grid reduction method based on the identifiable matrix needs to calculate the identifiable matrix before calculating the concept grid reduction and then obtain the identifiable function.

2.1.2. Concept Lattice Reduction Algorithm Based on New Discernibility Matrix. The reduction algorithm analyzes the deficiencies of the existing conditional information entropy in the process of knowledge reduction and gives a new conditional information entropy, which defines a new attribute importance. The attribute importance of entropy is compared. Reduction algorithm is one of the core content of rough set theory, and it also occupies an important position in intelligent information and data processing [15]. Information system is mainly divided into information table and decision table, but most encountered in real life is decision table, so the main consideration is decision table. For the attributes in the decision table, they are not equally important, and some of them are even redundant. Decision table, also known as judgment table, is a graphical tool in the form of a table, a precise and concise way of describing complex logic, mapping multiple conditions to actions to be performed when those conditions are met. Therefore, it is necessary to delete redundant attributes and perform attribute reduction, so as to obtain a concise, easy-to-use information system or decision table that can obtain useful value from it [16]. It allows users to better analyze the mining results and obtain valuable rule information.

Suppose that DIS_{FC} is the formal background, and $B_I \cup B_J$ difference attribute set is

$$DIS_{FC}(A_1, B_1), \left(A_J, B_J\right) = \begin{cases} B_I - B_J \\ \varphi \end{cases}. \tag{4}$$

DIS_{FC} is used to represent the set of non-empty elements in the discernibility matrix. Before calculating the reduction of the conceptual grid based on the new identifiable matrix, it is necessary to calculate the new identifiable matrix and then obtain the identification probability function.

2.1.3. Granular-Based Concept Lattice Reduction Algorithm. Granular is the basic concept in granular computing, which refers to the aggregation of objects under certain conditions or criteria, such as the aggregation of objects based on indistinguishability, similarity, or functionality [17]. An important task of knowledge discovery is to establish the relationship between granules, such as collections or concepts. This relationship can be represented by granular variables and granular values. The collection of granules is presented at a certain granularity through its constituent units. Granular computing immediately became a basic research problem of knowledge representation and data mining [18]. In the

Figure 1: Application areas of smart cities.

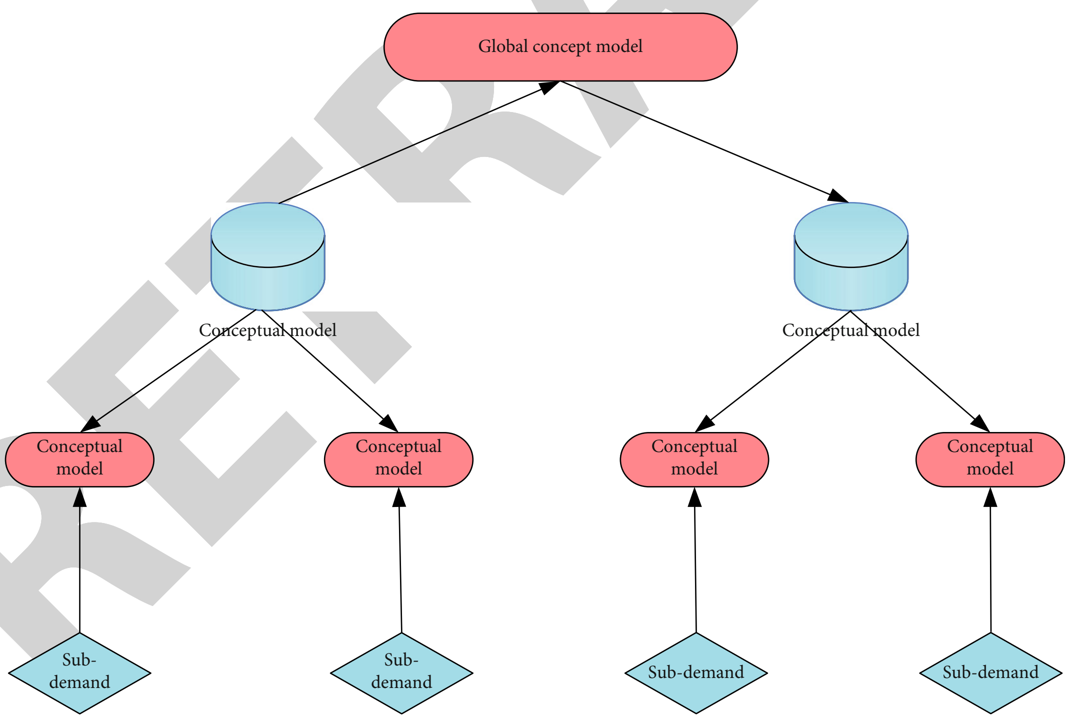


Figure 2: Conceptual clustering process.

concept lattice, the formal concept is derived from the formal background, and the formal concept is Formula (5)

$$(X, Y) = \vee(X^*, X^{**}). \quad (5)$$

Among them, (X^*, X^{**}) is the object concept, $(X^{*U}, X^{**}) \in U$ constitutes a basis of the concept lattice, the set of all object concepts reflects the granular information of the concept lattice, and $\{X^{**} | X \in U\}$ is called the object granule. For any attribute set $Y \subseteq X$, it is defined as

$$H_B = \left\{(x, y) \in u \times u, x^b \subseteq y^b\right\}. \quad (6)$$

Supposing that (U, A, I) is the formal background, then (x^*, x^a) is the formal concept in the formal background, and there is

$$(x^*, x^a) = \vee(x_1^{a*a}, x_1^a). \tag{7}$$

In rough set theory, reduction calculation can be converted into calculating the implication formula of Boolean variables. The article introduces this method to construct the recognition function according to the kernel and then obtains the granular reduction decision theorem [19]. A Boolean variable is a variable with two logical states, which contains two values: true and false. Boolean variables are often used as flags at runtime, such as for logic tests to change program flow.

Supposing (U, A, I) is the formal context, the attribute subset $Y \subseteq X$ is the granularity reduction, and $(x_1, x_2, \cdots, x_m)$ is the implication of the recognition function h_H. Among them, the recognition function h_H is defined as

$$h_H = h_H(x_1, x_2, \cdots, x_m) = \wedge\{\vee D : D \in M^*, D \neq \varphi\}. \tag{8}$$

Among them, $x_i, I = 1, 2, 3 \cdots, M$ refers to the Boolean variable corresponding to the attribute x_i, and $\vee D$ refers to the analytical formula of the Boolean variable corresponding to all the attributes in D.

According to the reduction definition and theorem, the minimum disjunctive normal form is obtained by simplifying according to the recognition function. To judge whether a certain attribute subset is a reduction, it is only necessary to judge whether the disjunctive normal form generated by the subset is the conjunctive normal form in the recognition function [20]. According to the analysis of the minimal terms, there is only one interpretation of the truth value of any minimal term that makes its truth value true, and the main disjunctive normal form is composed of the disjunctions of some minimal terms. In truth table technology, the truth value of the formula can be decomposed into some subformulas.

Supposing that the (U, A, I) is the formal background, its specific algorithm is described as

$$U_A(L(F)) = U_A(L(F_V)). \tag{9}$$

Then, V is said to be the object coordination set of F. If there is no proper subset of V that is the object coordination set of F, then V is said to be the object reduction set of F.

In order to conduct experimental analysis of reduction algorithms conveniently and intuitively, it is necessary to design graphics software that supports experimental analysis of reduction algorithms to prepare various input data uniformly and execute each reduction algorithm. According to the composition of the use case in the use case diagram, ASS can be divided into four small modules: One is the reduction algorithm module, which implements and manages all reduction algorithms, and provides the outside world with a call interface for executing the algorithm. The second is the input data module, which provides and manages all input data, and provides an interface for the outside world to select input data; the third is the trend graph module, which generates and displays the reduction algorithm execution time trend graph. The fourth is the control module, which coordinates the other three modules and uses the resources provided by the other three modules to provide external interfaces for the execution of control algorithms [21–23].

The control module monitors the ASS interface event. When the execution algorithm event occurs, the control module imports the selected input data into the algorithm according to the selected algorithm and automatically calls the algorithm execution interface. Finally, the algorithm execution time information is sent to the trend chart module, and its trend chart generation interface is called to automatically generate a trend chart, and finally the generated trend chart is shown in Figure 3.

As shown in Figure 3, it can be seen that the process of executing the reduction algorithm is the same, and the difference is the reduction algorithm executed. In order to effectively control the complexity of the program, the command mode in the software design mode can be used to design the control module that executes the algorithm that is to design each algorithm as a command, create an executor of the command, monitor various input events while the program is running, and automatically execute different algorithms according to the changes of input information.

Because the essence of attribute reduction is the process of deleting unnecessary attributes while keeping the classification ability of the information system unchanged, so when performing attribute reduction, the first problem to be solved in this article is how to judge the information system. The classification ability of the attribute set is in the middle. Some existing typical algorithms mainly use the equivalence class to measure the classification ability of the attribute set. This paper proposes a new method to measure the classification ability, which is to make full use of the tree structure.

For the convenience of the following explanation, this article first briefly introduces what is a two-dimensional table and classification tree. The two-dimensional table in Table 1 is a two-dimensional table. Each row describes an object, and each column describes a conditional attribute, as shown in Table 1.

As shown in Table 1, given a smart city information system, the corresponding two-dimensional table of the information system is the two-dimensional table of Table 1. The information system has 5 objects and 4 attributes.

Given an information system with 5 attributes and 5 objects, the corresponding two-dimensional table is shown in Table 2.

As shown in Table 2, the core of the information system is $\{A_1, A_2\}$, and the attribute reduction is $\{A_1, A_2, A_3, A_4\}$. The time complexity of the tree-based minimum attribute reduction algorithm is closely related to the number of attributes, so the tree-based minimum attribute reduction algorithm is more suitable for use in attributes. In a scene where the number is not very large, but the number of objects is large.

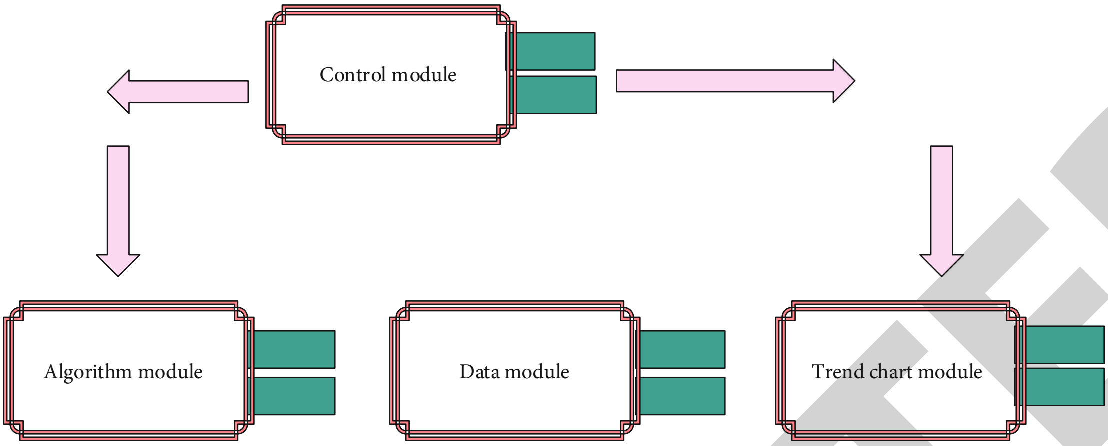


Figure 3: Data and message transfer diagram between ASS modules.

Table 1: Tree-based reduction algorithm.

U	A1	A2	A3	A4
1	1	2	0	1
2	2	0	2	0
3	0	1	1	2
4	2	2	1	1

Table 2: Two-dimensional table of tree-based reduction algorithm.

U	A1	A2	A3	A4	A5
1	2	0	2	2	2
2	1	1	1	1	1
3	0	2	0	1	2
4	1	1	1	0	0
5	0	1	2	0	1

This paper also compares the classification recognition rate, classification accuracy, and classification speed of the two algorithms, as shown in Table 3.

It can be seen from Table 3 that the classification speed of a single reduction algorithm is 38%, the classification accuracy rate is 42%, and the classification recognition rate is 39%. The classification speed of the tree-based reduction algorithm is 66%, the classification accuracy is 67%, and the classification recognition rate is 72%. It can be seen that the performance of the tree-based reduction algorithm is stronger than that of the single reduction algorithm.

Attribute reduction is one of the effective methods for data mining using rough set theory. Compared with other classification methods, it is also mentioned in the experiment that the reduction algorithm has higher classification recognition rate, faster speed, and energy consumption analysis. It is necessary to mine a large amount of data and classify and identify it, and the reduction algorithm can solve this problem.

This paper combines two methods of rough set reduction and concept lattice association rules to implement association rule mining. This will reduce the generation of candidate item sets, data mining ratios, scanning databases and a large number of redundant rules. The decision table algorithm based on the granularity of knowledge partition is a simple form that can reduce the performance of time and space and obtain an effective reduction set, reducing the number of conditional attributes and the scale of data mining. The data mining process is shown in Figure 4.

As shown in Figure 4, rough sets and conceptual grids are powerful tools for data analysis and knowledge processing, which are widely used in data mining and other fields. Deleting redundant attributes, reducing dimensional attributes, and reducing the scale of data mining is one of the important research contents in the field of rough set. Each node is essentially the largest set of items. According to the advantages of the visualization of hidden graphs, relevant rules can be mined. Therefore, it makes sense to use concept lattices to extract relevant rules.

Therefore, based on the above research, it is meaningful to combine the two methods of rough set reduction and related rule extraction for constructing conceptual grids. It can not only reduce the candidate item set, data mining ratio, and scan database generation, as well as the generation of a large number of redundant rules, but also improve the efficiency and accuracy of mining.

Rule $x \Rightarrow y$ is established in transaction set D; it has support, denoted by t; and t is the percentage of transaction containing $x \cup y$ in transaction set D, that is, $p(x \cup y)$, which is defined as

$$t = \sup port(x \Rightarrow y) = p(x \cup y) = \frac{|(x \cup y)|}{|D|}. \tag{10}$$

The support of rule $x \Rightarrow y$ represents the percentage of the total number of simultaneous occurrences of item set x and item set y in transaction set D, indicating the probability of item set x and item set y occurring at the same time.

Supposing that the rule $x \Rightarrow y$ has the confidence in transaction set D, represented by q, and q is the transaction set D, under the condition that the transaction contains x,

Table 3: Performance comparison of the two algorithms.

	Classification speed	Classification accuracy	Classification recognition rate
Single parsimony algorithm	38%	42%	39%
Tree-based parsimony	66%	67%	72%

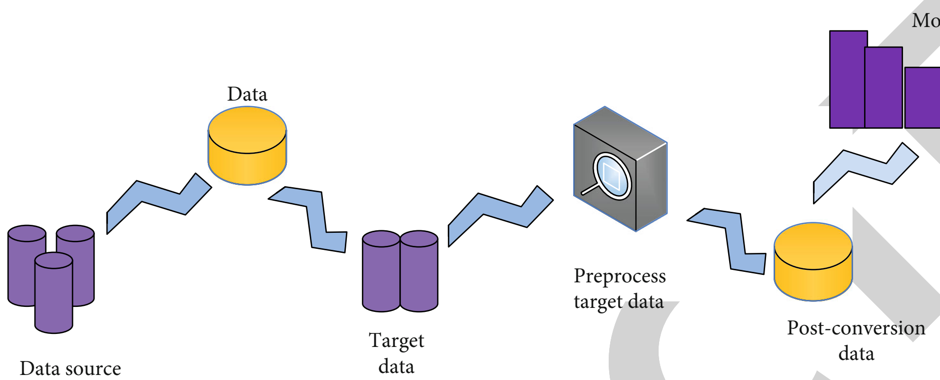


Figure 4: Data mining process.

the percentage of y, that is, $p(x|y)$, is defined as

$$q = \sup port(x \Rightarrow y) = p(x|y) = \frac{\sup port|(x \cup y)|}{\sup port|x|}. \quad (11)$$

Rule $x \Rightarrow y$ has the expected credibility in transaction set D, denoted by y, and y is the percentage of P transactions in transaction set D, that is, $p(y)$, which is defined as

$$ec = \exp ectedconf idence(x \Rightarrow y) = p(y) = \frac{|y|}{|D|}. \quad (12)$$

The expected credibility of rule $x \Rightarrow y$ represents the percentage of transaction P in transaction set D, and is not restricted by any circumstances.

Rule $x \Rightarrow y$ has a degree of action in transaction set D, denoted by L, as

$$L = lif t(x \Rightarrow y) = \frac{\sup port(x \Rightarrow y)}{\exp ectedconf idence(x \Rightarrow y)}. \quad (13)$$

The two measures of rule interest of the rule are support and confidence, which represent the main properties of association rules.

2.2. Rough Set Theory. The research on rough set theory mainly focuses on the classification knowledge formed by the domain U. Among them, the division here is equivalent to the equivalence relationship in mathematics. Generally, the corresponding division is carried out through the equivalence relationship, and then the knowledge or information is expressed. The rough set theory is shown in Figure 5.

As shown in Figure 5, here, the equivalence relationship represents the split, and various knowledge derived from the equivalence relationship is represented by the knowledge base.

Supposing that the U is a universe of discourse and A is a set of equivalence relations on the domain of discourse and satisfies $H \subseteq A$, where $H \neq \varphi$, then $IND(H)$ is an indistinguishable relation on H, which is

$$IND(H) = \left\{(a, b) \middle| (a, b) \in u^2, \forall h \in H\right\}. \quad (14)$$

Here, $\forall h \in H$ is defined as the knowledge related to the equivalence relationship $IND(H)$, which is called the basic knowledge about the universe U in the knowledge base $(a, b) \in u^2$.

Given a knowledge base $(a, b) \in u^2$, where U is the domain of discourse, and A is the equivalence relation cluster of U, for $\forall_A \in U$ and an equivalence relation $R \in IND(H)$, the subset A is defined as:

$$R(A) = \left\{A \middle| [A]_R \cap A \neq \varphi, \forall_A \in U\right\}. \quad (15)$$

It can be seen from Formula (15) that for the upper approximation $R \in IND(H)$ of the universe U, in an information system or decision table, any attribute reduction is equivalent to its basic category, that is, their ability to classify knowledge is equivalent. Generally speaking, attribute reduction is not unique. An information table or a decision table can have multiple reduction sets. The intersection of these multiple reduction sets forms a core.

For $\forall R \in H$, call R necessary in P, which is

$$IND(H - \{R\}) \neq IND|H|. \quad (16)$$

And, all the necessary knowledge in H is called the core of H, denoted as COREP(H).

Generally, the most considered in practical applications is the decision table, and the decision table is mainly divided into condition attributes and decision attributes. The classification of the condition attributes on the decision table is

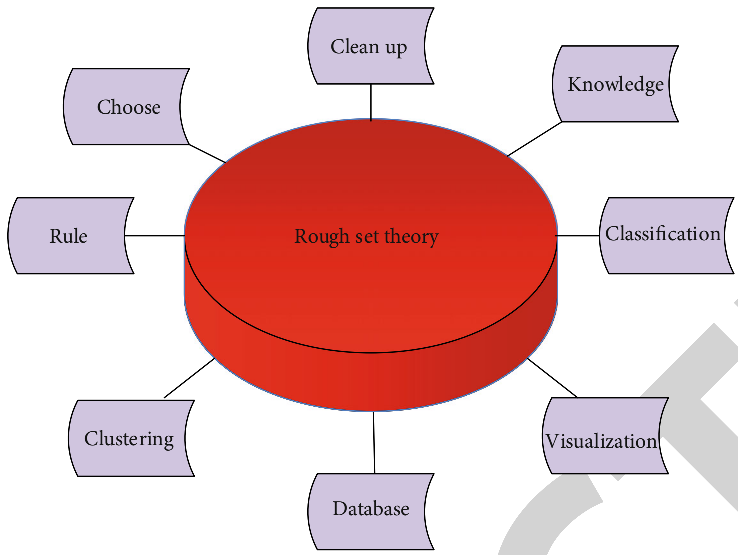


Figure 5: Rough set theory.

very important for the classification of the decision attributes on the decision table.

$pos(w)$ is called the positive domain of knowledge W relative to knowledge H, which is

$$pos(w) = H(A) \cup H(B). \tag{17}$$

Let U be a universe of discourse. For $\forall R \in H$, if Formula (18) is satisfied:

$$pos_{IND(H)}(IND(W)) = pos_{IND(W-\{R\})}(IND(W)). \tag{18}$$

It is unnecessary to call knowledge R as H; otherwise, it is necessary.

Supposing that U is a universe of discourse, V is an equivalence relation on the domain U, and the division derived from the domain U is $A = \{A_1, A_2, \cdots, A_m\}$, then the division granularity of knowledge V is defined, expressed by $G(V)$, and satisfies

$$G(V) = \sum_{i=1}^{m} |A_i| P(A_i) = \sum_{i=1}^{m} |A_i| \frac{|A_i|}{|U|}. \tag{19}$$

Supposing that U is a domain of discourse, V and D are two equivalent relations on domain U, and the divisions derived from domain U are $A = \{A_1, A_2, \cdots, A_m\}$ and $B = \{B_1, B_2, \cdots, B_m\}$, respectively. Then, define the division granularity of knowledge D relative to knowledge V, which is represented by $G(D|V)$ and satisfies

$$G(D|V) = \sum_{i=1}^{m} \begin{cases} \sum_{j=1}^{m} \frac{|A_I|}{U}, A_I \subseteq B_J \\ 0, A_I \not\subset B_J \end{cases}. \tag{20}$$

Generally speaking, attribute reduction starts from the core, and according to the importance of the attributes, the attributes with high importance are selected in turn until the requirements are met. Another method is to start with the attribute set, delete the attributes with low importance one by one, and add them to the core according to the importance of the attributes until the requirements are met.

3. Experiment and Analysis Based on Smart City Development Survey

3.1. Experiment and Analysis of the Development of Smart Cities and the Energy Consumption Generated. The construction of a smart city involves all areas of urban life. In order to improve people's quality of life and urban competitiveness, technical means are mainly used to improve the economic and political efficiency of the city. Currently, smart city information support technologies include smart identification, mobile computing, cloud computing, and the Internet of Things. With the development of new technologies in the future, more technologies will be derived. The abovementioned technologies are widely used in smart transmission, smart healthcare, smart education, smart grid, etc., in smart cities. With the development of smart city construction, the focus of attention is no longer limited to the hardware fields such as infrastructure, and people are also beginning to pay attention to the culture and environment of the city.

In order to identify the main influencing factors of smart city construction and development and to understand the opinions of government enterprises and related research personnel on these influencing factors, this paper designs a survey on the influencing factors of smart cities, as shown in Table 4.

As shown in Table 4, the subjects of this questionnaire survey mainly include government agencies, smart city construction companies, and related research institutions. The impact of different influencing factors on smart cities can be understood from multiple perspectives.

Table 4: Factors influencing smart city.

Survey object	Quantity	Percentage	Effective recovery rate
Government department	50	21%	21%
Related business	57	24%	24%
Colleges	60	28%	28%
Citizen	70	29%	29%

Table 5: Number of smart city pilot projects and investment scale from 2009 to 2015.

Years	Number of smart cities	Investment scale	Growth rate
2009	7	3432	3%
2010	8	3895	3.2%
2011	10	4567	3.7%
2012	13	6578	5%
2013	15	7890	5.8%
2014	19	8973	12%
2015	21	9080	16%

This paper conducts a survey on the number and investment scale of smart city pilots from 2009 to 2015, as shown in Table 5.

As shown in Table 5, the number of smart city pilots from 2009 to 2015 is increasing, and the scale of investment is also increasing. This represents the country's emphasis on smart cities and people's recognition of smart cities.

This article compares the development trends of smart cities in 2017 and 2018, as shown in Figure 6.

As shown in Figure 6, the development trend of smart cities from 2017 to 2018 has been on the rise, from 6% to 16%. It can be seen that smart cities are becoming more and more popular with people and their development is getting faster and faster.

In the context of smart cities, the energy-saving monitoring system of large-scale public buildings serves as a building energy-saving public relations service platform, providing social public energy-saving information services, supporting administrative decision-making, and providing a foundation for the goal of ecologically sustainable city construction. The overall goal of the energy consumption monitoring system for large-scale public buildings in smart cities is to establish an energy consumption monitoring system for large-scale public buildings in the whole society to monitor the energy consumption of major cities and major buildings in real time. At the same time, through energy-saving evaluation, energy-saving optimization, energy-saving publicity, energy-saving distribution, etc., promote the improvement of energy-saving use and management level, and use large-scale public buildings to develop into a high-energy-consuming building energy-saving service market.

This article investigates and compares the main ways to generate energy consumption from 2012 to 2017, as shown in Figure 7.

As shown in Figure 7, considering the global urbanization trend, cities must provide a continuous supply of energy for industrial and commercial activities, transportation, construction and infrastructure, water supply, and food production. Researchers found that cities consume 75% of the world's energy, of which the production of electricity and heat is the largest source of greenhouse gas emissions, followed by sectors such as agriculture, industry, transportation, and construction.

As we all know, power generation methods are mainly thermal power generation, hydropower generation, atomic power generation, etc., and cannot store the power generation energy of power stations. Power stations only use past data and can predict future power generation. In order to provide accurate power generation capacity guidance, it is necessary to accurately predict the power consumption based on the data reported by the smart meter, because this is an important plan for predicting the same power and accurate power consumption of the generated energy. On the other hand, based on the power consumption information, it is possible to grasp the power demand of each area and improve the accuracy of the plan.

This paper investigates 5 well-running machines and 6 machines that have been worn out, as shown in Table 6 and Table 7.

As shown in Table 6, the working efficiency of the five well-running machines is between 78% and 94%, and the failure score is between 0 and 3, indicating that there are still very few failures, and the operating efficiency is very high at this time.

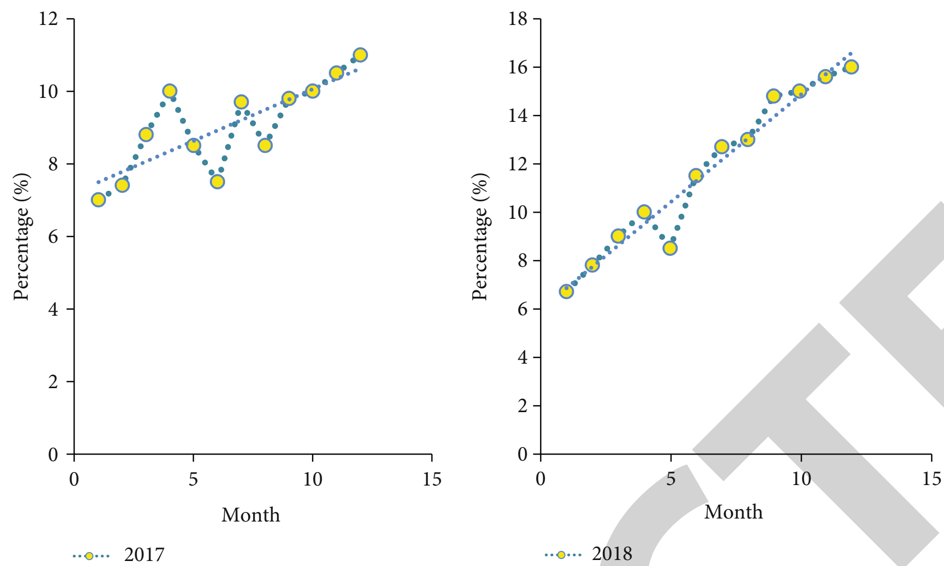
As shown in Table 7, the working efficiency of the five lossy machines is between 24% and 43%, and the failure score is between 7 and 9, indicating that there are many failures, and the operating efficiency is also very low at this time.

In this paper, the energy consumption generated by these two sets of machines is investigated and statistics, as shown in Figure 8.

As shown in Figure 8, the unhealthy operation of building electrical equipment under fault conditions not only reduces the energy efficiency of its operation, and it will reduce the stability of the system and shorten the service life of the system and equipment. The most important thing is that the energy consumption is very high.

This paper selects the equipment failure rate as the evaluation index, focuses on monitoring the electrical equipment with high equipment failure rate, and discovers its abnormal energy usage in time, which is of great significance to achieve building energy conservation, improve system stability, and reduce operation and maintenance costs.

3.2. Measures to Reduce Energy Consumption. The reduction of energy consumption is now a very important issue, and the IoT smart city is one of the solutions. In the smart city concept, the use of IoT sensors and other technologies can help cities save resources and reduce energy consumption. Smart cities start from all aspects of urban infrastructure, collecting data on roads, bridges, railways, communications,



(a) The development trend of smart cities in 2017 (b) The development trend of smart cities in 2018

Figure 6: The development trend of smart cities from 2017 to 2018.

Figure 7: The main ways to generate energy consumption from 2012 to 2017.

Table 6: The running status of 5 well-running machines.

Machine	Operation hours	Operating efficiency	Failure score
1	32	78%	3
2	35	89%	2
3	34	85%	1
4	32	94%	0
5	31	79%	2

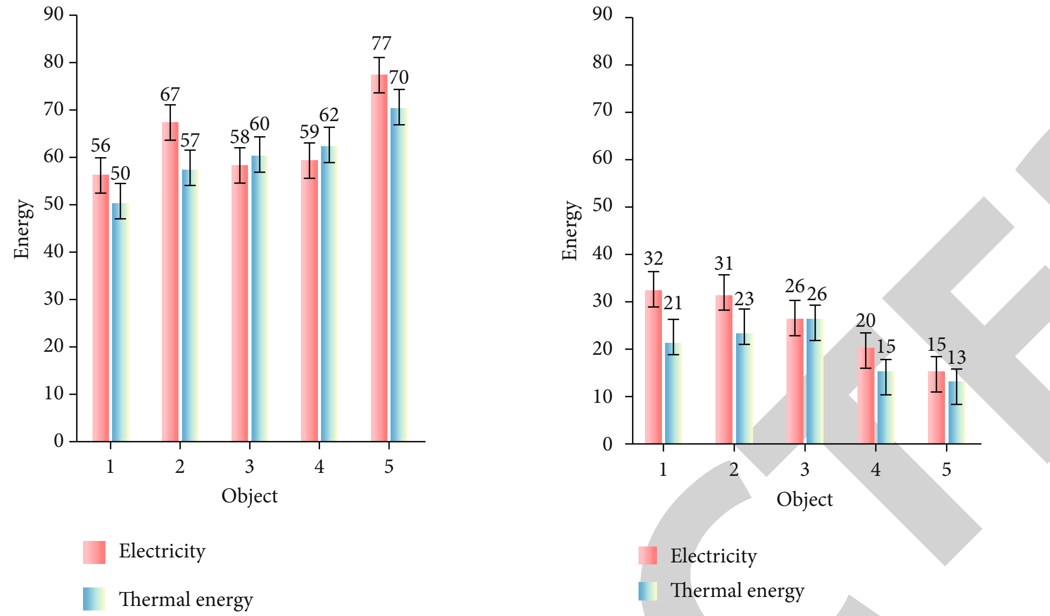
Table 7: Five machines that have been worn out.

Machine	Operation hours	Operating efficiency	Failure score
1	32	43%	7
2	35	40%	7
3	34	36%	9
4	32	38%	8
5	31	24%	9

water, electricity, and major buildings. In addition, scientific predictive analysis and applications are used to process the collected data to improve the efficiency of service providers and improve the quality of life of citizens.

(1) Smart grid

Smart grids are equipped with sensors that can collect and send data about electricity supply and usage. The



(a) Energy consumption generated by 5 lossy machines (b) Energy consumption generated by 5 well-functioning machines

Figure 8: Energy consumption generated by the two sets of machines.

purpose is to improve efficiency through more effective management and control of electrical products and systems, minimize the impact on the environment, and reduce overall costs.

(2) Efficient public lighting

Effective public lighting is another area of IoT smart cities, providing space to reduce energy consumption. The solution that can be thought of here is to use LED-based street lights enhanced by intelligent control and motion sensors, which can automatically switch on and off as needed.

4. Discussion

This article analyzes how to analyze the energy consumption of smart cities based on the reduction algorithm. The energy consumption of smart cities is studied, the reduction algorithm and the related concepts of smart city are explained, and the reduction algorithm based on rough set theory is studied. The related theoretical knowledge is expounded on the reduction algorithm, and the research method of the reduction algorithm is explored. And through the experiment and analysis of various algorithms, the importance of the reduction algorithm for analyzing the energy consumption of smart cities is discussed. Finally, the analysis is carried out by taking the reduction algorithm integrated into the smart city energy consumption analysis as an example.

This paper also makes reasonable use of rough set theory based on reduction algorithm and association rules in data mining. As the scope of data mining applications has become larger and larger, and its importance has also increased, many scholars have begun to apply data mining to all aspects of life. According to these two algorithms, based on the reduction algorithm and data mining, the impact of the analysis of smart city energy consumption analysis is far-reaching.

Through experimental analysis, it is known that as the number of smart city pilots increases, the energy consumption is also increased, and the required resources are also increasing. However, resources such as electricity and heat are in short supply, so it is of great significance to study how to reduce energy consumption.

5. Conclusions

This article gives a specific introduction to the reduction algorithm and the concept of smart city, puts forward the specific algorithm of the grid reduction algorithm in the method part, and analyzes the energy consumption of smart cities through the reduction algorithm. Through the investigation method, the experiment in this article knows: In recent years, with the growth of smart cities, more and more energy consumption has been generated. The increase in energy consumption means the destruction of resources. Therefore, how to reduce energy consumption while creating a smart city is a difficult problem that needs to be solved at present, solutions for reducing energy consumption in smart cities, including but not limited to smart meters and smart public lighting. They have played a significant role in reducing energy costs, reducing greenhouse gas emissions, and improving urban living standards. Energy departments in major cities have also begun to implement sensors and networks to reduce energy consumption and contribute to the development of the Internet of Things. The new urban energy situation makes people must carefully consider how to save resources and reduce energy consumption.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflicts of Interest

The author states that this article has no conflict of interest.

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