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Using Neighborhood Rough Set Theory to Address the Smart Elderly Care in Multi-Level Attributes

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Abstract: The neighborhood rough set theory was adopted for attributes reduction and the weight distribution of condition attributes based on the concept of importance level. Smart elderly care coverage rate is low in China. A decisive role in the adoption of smart elderly care is still a problem that needs to be addressed. This study contributes to the adoption of smart elderly care was selected as the decision attribute. The remaining attributes are used as conditional attributes and the multi-level symmetric attribute set for assessing acceptance of smart elderly care. Prior studies are not included smart elderly care adoption attributes in multi-levels; hence, this problem needs to be addressed. The results of this study indicate that the condition attribute of gender has the greatest influence on the decision attribute. The condition attribute of living expenses for smart elderly care has the second largest impact on decision attribute. Children's support for the elderly decency of the novel elderly care system and the acceptance of non-traditional elderly care methods belong to the primary condition attribute of traditional concept. The result indicates traditional concepts have a certain impact on the adoption of smart elderly care and a condition attribute of residence also has a slight influence on the symmetric decision attribute. The sensitivity analysis shows the insights for uncertainties and provides as a basis for the analysis of the attributes in the smart elderly care service adoption.

Keywords: smart elderly care; neighborhood rough set; attributes reduction; sensitivity analysis; symmetric attribute

1. Introduction

The neighborhood rough set theory after the overlapping attributes are deleted, and the degree of influence of the attributes on the adoption behavior of smart elderly care is analyzed. The main purpose of attribute reduction is based on neighborhood rough set to eliminate redundant attributes classified data and extract useful information. Firms' business methods are changing from product-centric to

consumer-centric firms satisfy consumer needs and make changes to avoid blindness of firm decisions to improve firm services and competitiveness with consumer data through rough sets [1]. One of usable application of Rough set theory is the processing of discrete data. This study is necessary to discretize the data when processes continuous data. The drawback of this application is a large amount of information loss, and the discrete data cannot accurately reflect the classification of information [2]. The proposed neighborhood rough set model effectively solves the problem of symmetric attribute reduction of numerical and continuous value information systems [3,4]. The neighborhood rough set theory applies to reduce the smart elderly care attributes, and continuous attribute values are directly processed without data discretization to improve the reduction result accuracy.

China is facing a severe aging trend, and the population aged 60 and over recently reached accounting for 17.9% of the total population according to data released (National Bureau of Statistics, 2018). Meanwhile, the elderly population may have some health problems as they get older. Nearly 180 million elderly people suffer from chronic diseases and 40 million disabled people need professional care. Insufficient resources for the elderly and the problem of aging have increasingly serious, and the smart elderly care industry has gradually developed with the advent of the tide of silver hair and technology [5,6]. Smart elderly care refers to the use of advanced information technology to develop the Internet of things system platform for the elderly at home communities and institutions and to provide real-time fast, efficient Internet of Things and smart services. The emergence of smart elderly care greatly improves endowment efficiency reduces costs and optimizes resource allocation [7–9]. However, the existence of information silos and the digital divide affect the elderly's attitudes willingness and satisfaction with smart and technological products [10–12].

This study divides the main influencing attributes of the adoption of smart elderly care into eight aspects, such as the symmetric condition of family and health using attitude trust perception, useful perception, easy-to-use perception, cost perception, and subjective norms. There are various methods to reduce the attributes of the information system. Prior studies put forward different attribute reduction methods.

(1) Singular value decomposition: This method has a good effect when the data dimension is high, and it is often used as a preprocessing method to realize the convergence of fuzzy rough reduction in high-dimensional data sets; but the calculation cost of this method is high [13,14];
(2) The principal component analysis is reduced, and the mutual influence between evaluation indexes is eliminated by replacing the original variables with several principal components with larger contributions. This study is necessary to delete irrelevant or unimportant attributes to eliminate the interference of irrelevant features when using the data with higher dimensions [15];
(3) Effective feature extraction in deep learning: Data-driven deep learning analysis has been developed and applied in many fields. The ability to fit and extract features has been improved by combining multiple processing layers in a variety of data analysis tasks [16];
(4) The attribute reduction of rough set theory is an extension of the theory of modeling ambiguity and imprecision [17]. The designed attribute table is composed of multiple, highly reliable symmetric attributes in the adopted theoretical model. There are overlapping among the various attributes, and the symmetric attributes should be deleted to prevent their reduction effects [18–20].

The structures of this study are as follow. The second part introduces the development status of smart services and this study status of neighborhood rough set theory. The third part introduces the principle of neighborhood rough set theory and the calculation steps of condition attribute importance. The fourth part is based on the calculation results analyze the impact of conditional attributes on the adoption behavior of smart services and verify results. The fifth part introduces the main scientific contributions of this article. The sixth part summarizes the outlook for smart services.

2. Literature Review

Rough sets theory is to deal with inaccurate discontinuous and other incomplete information [21–23]. Rough set theory analyzes incomplete data find out the relationship between the data and extract core data to overcome the subjectivity of traditional method evaluation parameter selection. The attribute reduction based on the rough set is used to process the data collected by the smart elderly care. The complex problems that arise in society transformed into data and processed [24–26]. In addition, Thuy and Wongthanavasu proposed a method for a fast, deterministic reduction based on conditional information entropy and defined the original concept of attribute reduction based on the stripped quotient set and proposed an effective SRED algorithm [27]. This algorithm may not be applicable to other data sets and has certain limitations and needs to be improved in the future. Lei et al. proposed to combine rough sets and wavelet neural networks [28]. The structure of wavelet neural networks was optimized using rough sets to reduce the redundant attributes of the data that is to accurately evaluate the indoor air quality level that comprehensive evaluation based on rough sets and wavelet neural networks and the computational efficiency is high, but the accuracy of the rough set attribute recognition after reduction is low.

For large data sets, this algorithm is effectively shortened the calculation time. However, this algorithm has yet to be studied for handling the incremental attributes of dynamic decision tables. Chen et al. proposed a fast heuristic attribute derivation algorithm using Spark's energy data, which used an efficient energy consumption decision table conversion algorithm and a heuristic formula for measuring the importance of symmetric attributes to reduce search space and introduced the correlation between condition attributes and symmetric decision attributes [29,30]. This algorithm may not be applicable to other data sets and has certain limitations, thereby, further improving the computational efficiency. Che and Mi defined the multi-granularity variable precision rough set by considering the importance of each attribute set relative to all attribute sets and studied the attribute set reduction by combining the smallest element of the distinguishable matrix and distributed distinguishable function [31]. Abbas et al. proposed a novel context information selection process using soft rough sets [32].

Smart elderly care is known as smart home services which means that various information of the elderly is monitored at anytime, anywhere and comprehensively through technologies, such as the Internet of Things [7,33]. The smart elderly care originates from intelligent city development. 'Intelligent city' refers to the use of various information technologies or innovative concepts to connect and integrate urban systems and services to improve the efficiency of resource use optimize urban management and services and improve the quality of life of citizens [34]. Most cities have actively promoted the technological and information-based public service functions, which have also created objective conditions for the intelligentization of elderly care services [35,36]. Under the background of increasing aging, government and society strives to explore the potential of elderly care technology in the fields of biology psychology society and medical care and builds a comprehensive service platform for the elderly and health care to integrate medical services operators service providers and individuals. Families are connected to meet the diverse and multi-level needs of the elderly [37,38].

With the development of scientific and technological informatization level, the intelligent products of modern communication and network technology play an increasingly significant role in the aging service industry; especially, in the areas of telemedicine health management and home care service information platforms. The trend of intelligence and Informatization are presented in past studies [39–43]. For instance, smart elderly care greatly expands the scope of demand response with information technology enriches the breadth and depth of services and injects fresh blood into the entire industry [41]. This study is not only to understand whether the willingness accepts smart elderly care services, but also analyze to deepen the study and is to collect the willingness to adopt such aspects as the usefulness and ease of use of smart services.

The proposed model is used the importance assignment process of soft rough sets to select the minimal set that affects the context. The algorithm has been extensively evaluated using the

LDOS-CoMoDa data set and accuracy of context sparsity methods by utilizing relevant context symmetric attributes whether the idea of combining soft rough sets and decision technology is extended to other domain areas. Zhang et al. introduced the similarity of universal decision preservation and on this basis, put forward countermeasures of internal meaning and external meaning [44]. Two fast reduction algorithms for general decision retention are developed by using heuristic strategies. The proposed heuristic attribute reduction algorithm is based on equivalence relations and only be used in the classic Pawlak decision system. Wang et al. proposed a neighborhood rough set model called k-nearest neighborhood rough set and combined the advantages of δ-neighborhood and k-nearest neighbors to handle heterogeneous data than existing models; still, it is not clear enough to describe the neighborhoods of category mixed samples [45]. Prior studies have found defects and proposed their own innovations to improve the algorithm.

A novel rough analysis theory based on neighborhood rough set theory is proposed to analyze the symmetric demand attributes of smart elderly care service and to avoid the low accuracy of data analysis and speed up the analysis of the importance of condition attributes. In addition, classified and preprocessed to determine the decision attribute and condition attribute the condition attributes are sorted classified and displayed in the form of a graph to facilitate attribute assignment data analysis and weight distribution. Neighborhood rough set theory calculates the importance of each condition attribute and selects the condition attribute with high importance as the main factor affecting the acceptance of smart elderly care. All programs are run in MATLAB R2016a simulation environment to ensure the accuracy of data analysis. The simulation results show that the neighborhood rough set theory can realize the prediction of the main demand attributes of smart elderly care service.

3. Method

3.1. The Theorem of Neighborhood Rough Set

Definition 1. *$S = (U, Z, V, f)$ is an information system in which U called the universe is a non-empty set of study objects; Z is the attribute set, including C conditional attribute set and D the decision attribute set that is $Z = C \cup D$ and $C \cup D \neq \varnothing$; f is a mapping. Object U is mapped to obtain V_Z under the condition of the attribute set Z. This has an equation $V = \cup_{z \in Z} V_Z$ so V is a collection of attribute values [23,24,45].*

Definition 2. *According to the attribute set Z the division of the universe U is written as: U/ind (Z) or U/Z [45].*

Definition 3. *For any $x_i \in U, c \in C$ on the condition of the attribute subset c the neighborhood $\delta_B(x_i)$ of x_i on is defined as $\delta_B(x_i) = \left\{ x_j \middle| x_j \in U, \Delta_B\left(x_i, x_j\right) \leq \delta \right\}$ where δ is the metric function [45].*

Definition 4. *For any $X \subseteq U$, the lower and upper approximations of the neighborhood approximation space of X and the approximate boundary are defined as [45]:*

$$\overline{N}X = \{x_i | \delta(x_i) \cap X \neq \varnothing, x_i \in U\} \quad (1)$$

$$\underline{N}X = \{x_i | \delta(x_i) \subseteq X, x_i \in U\} \quad (2)$$

$$BNX = \overline{N}X - \underline{N}X \quad (3)$$

and, $\underline{N}X \subseteq X \subseteq \overline{N}X$ is proposed.

Definition 5. *Given a sample set U, $U = \{x_1, x_2, x_3, \ldots, x_n\}$, A is a real-numbered feature set describing U and D is a decision attribute set in a neighborhood decision system. If A generates a family of neighborhood relationships on the universe $NDT = (U, A, D)$ is a neighborhood decision system [45].*

Definition 6. *For NDT = (U, A, D), the decision attribute D divides the universe U into N equivalent classes $X_1, X_2, \ldots, X_N$ and for any $B \subseteq A$, the upper and lower approximations of decision D with respect to B are defined as [46]:*

$$\overline{N_B}D = \bigcup_{i=1}^{N} \overline{N_B}X_i \tag{4}$$

$$\underline{N_B}D = \bigcup_{i=1}^{N} \underline{N_B}X_i \tag{5}$$

The positive region of the decision $Pos_B(D)$ is numerically equal to lower approximations, which is defined as $Pos_B(D) = \underline{N_B}X$.

Definition 7. *For NDT = (U, A, D) the dependence of decision attribute D on condition attribute B is defined as [46]:*

$$\gamma_B(D) = \frac{\left|Pos_B(D)\right|}{|U|} \tag{6}$$

where $|\cdot|$ is the norm of the set.

Definition 8. *Given the NDT (U, A, D) for any $\alpha \in B$, the significance of α in B is defined as [46]:*

$$Sig(a, B, D) = \gamma_B(D) - \gamma_{B-\{\alpha\}}(D) \tag{7}$$

Definition 9. *Approximate accuracy, also called classification accuracy, is proposed to describe the accuracy of the boundary domain of a set. The approximate accuracy of a set X defined by the equivalent relationship N is [46]:*

$$\alpha_N(X) = \frac{\left|\underline{N}X\right|}{\left|\overline{N}X\right|} \tag{8}$$

3.2. Steps to Calculate Importance Based on Neighborhood Rough Set

(1) Processing of questionnaires.

Data from the questionnaire shows that the proportion of the elderly living alone is 20.3%, the proportion of couples taking care of each other in daily life is 34.7% and the elderly who have no knowledge of smart elderly care services account for 35.1% of the total number. The data shows that the life of the elderly requires more investment and care from society. Smart elderly care services solve these problems more effectively, but the elderly population does not know much about smart care services for the elderly population. Therefore, the method is needed to study what factors play an important role in the use of smart elderly care services. This study uses the questionnaire answered by everyone in the survey report as a universe (U) and uses 31 attributes, such as gender age number of children and living style as conditional attributes (C) and whether to adopt smart services as decision attribute (D). Multi-level attribute set of smart elderly's acceptance is set.

(2) Establishing the multi-level attribute framework.

The block diagram of the multi-level attribute set for predicting the main demand symmetric attributes of smart elderly care services is shown in Figure 1. The weight of each condition attribute is smaller after reduction attribute reduction is performed before classifying the condition attributes, which is convenient for the weight distribution and data analysis after the attribute reduction.

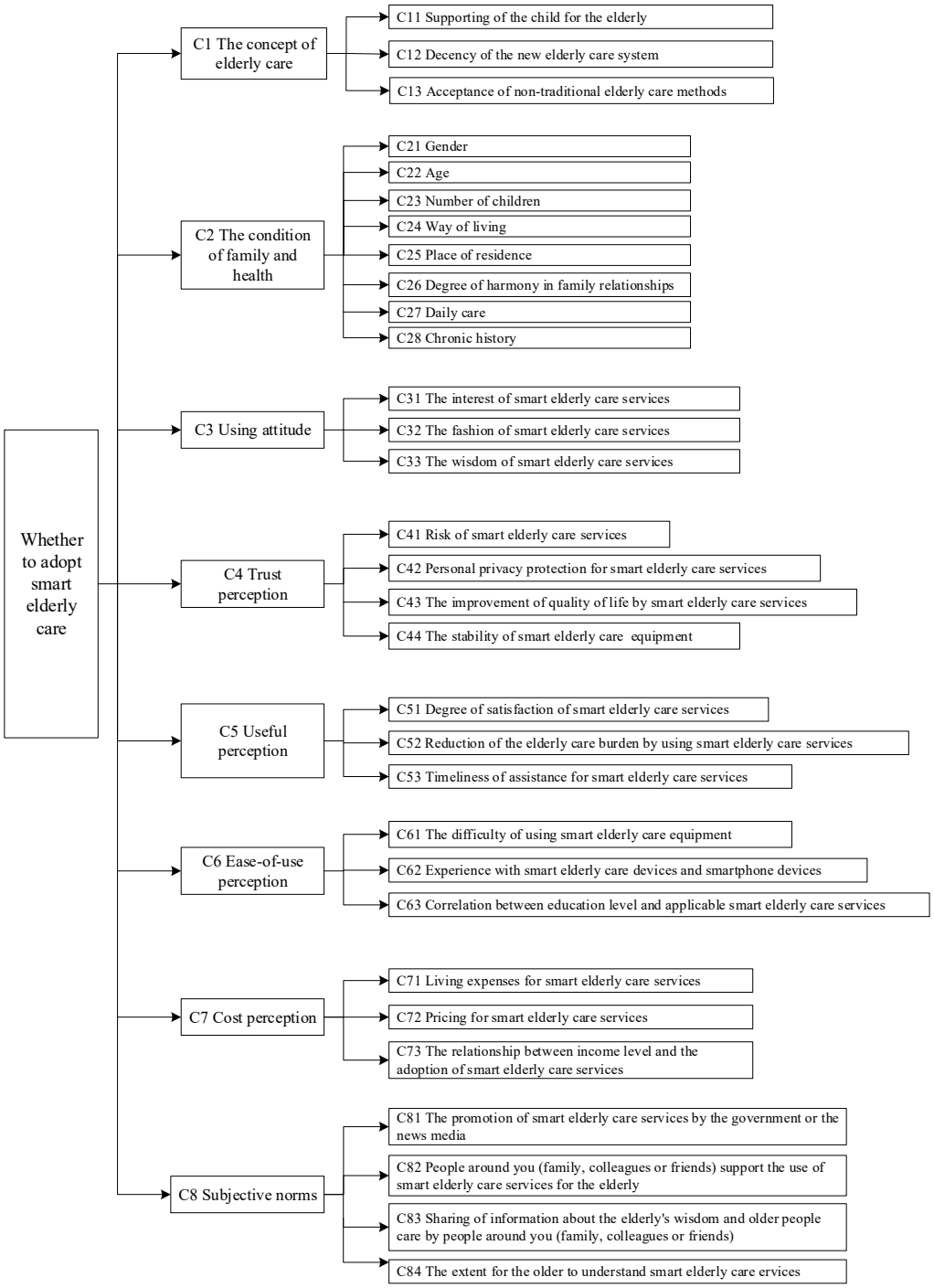

Figure 1. Multi-level attribute set block diagram of acceptance for smart elderly care.

For instance, Liu et al. constructed a two-level risk evaluation system with a total of nine risk attributes in three dimensions to conduct a comprehensive risk evaluation of the wiper arm control system [47]. When evaluating the scraper arm control system failures, a large number of risk attributes must be considered to ensure all fault types can effectively respond, and the validity of fault assessment is needed. A hierarchy of risk attributes for fault assessment needs to be constructed. There may be linear and non-linear relationships between process variables in complex industrial processes, which present challenges to process reliability monitoring. Prior studies did not consider the relationships among different levels monitoring all variables to reduce accuracy and monitoring

performance. Li et al. proposed a hierarchical monitoring strategy to capture different levels of linear and non-linear modes to improve fault detection capabilities [42,48]. Qian et al. proposed a hierarchical data reduction algorithm based on MapReduce for big data [49]. A hierarchical coding decision table was established then the relationship between the decision table levels was discussed, and parallel classes of equivalent classes were designed to parallel calculation of the importance of attributes and attributes reduction which solves the problem that traditional rough set algorithm cannot handle large data sets. Similarly, a multi-level attribute set for the attribute reduction in the case of big data is constructed when analyzing the main demand attributes of smart elderly care services, so that the reduction algorithm can process data more efficiently [38].

The relationship between the upper and lower levels of the attribute set in Figure 1. Under the influence of traditional filial piety culture children's care for the elderly has become a lifestyle and order. There is clear conflict and confrontation between the traditional filial piety culture and the novel way of supporting the elderly. The elderly care concept C1 in Figure 1 should be included in smart services adoption behavior. The corresponding conditions C11 to C13 belong to the attributes developed to measure the elderly care concept C1. The C2 family and health status, including conditional attributes C21–C28 are used for the statistics of basic conditions of the elderly. Use attitude is the user's opinion and evaluation of things based on their own emotions and values, including likes or dislikes of things positive or negative effects of things and positive or negative of the overall evaluation of things [50]. The two major constructs of using attitude C3 and subjective norm C8 are derived from the theory of reasoned action and theory of planned behaviors through appropriate adaptations, and those attributes have been made into attributes C31–C33 and C81–C84.

The elderly's trust in smart elderly care mainly involves privacy security trust functional trust, service trust, and device reliability trust [51]. The concept of trust perception C4 is derived from the Integrated Technology Acceptance Model. The conditional attributes C41–C44 are smart behavior measures for the elderly based on the trust perception. Usefulness perception is the degree to which a user believes that a product or technology is helpful to the performance or daily life after using it. Usability perception is the degree to which a product or technology is easy for users to learn and use [52,53]. The two constructs of usefulness perception C5 and usability perception C6 come from the technology acceptance model. The corresponding condition attributes C51–C53 and C61–C63 are adapted. Cost perception C7 includes whether new investment is needed by the user, and continuous maintenance costs are required to increase daily expenses. Analysis attributes, such as C71–C73 are obtained by analyzing the technical characteristics of smart elderly care. The usefulness perception C5 and the usability perception C6 are derived from the Technology Acceptance Model. The corresponding conditional attributes C51–C53 and C61–C63 are adapted. Cost perception C7 includes whether new investment is needed by the user, and continuous maintenance costs are required to increase daily expenses. Attributes C71–C73 are obtained by analyzing the technical characteristics of smart elderly care. The multi-level attribute set block diagram of acceptance for smart elderly care is shown in Figure 1.

Figure 1 presented the practical application background of decision making for smart elderly care the multi-level attribute set of the main demand attributes for smart services includes three layers. The first-level condition attribute set includes the influencing attributes of "Whether or not to adopt smart services" which are summarized as the concept of the elderly's care, the condition of family and health, using attitude, Trust perception, Useful perception, Ease-to-use perception, Cost perception and subjective norms constitute the second layer of this multi-level attribute set. The 31 s-level condition attributes, such as decency of novel-style care for the elderly and place of residence are the third layer of the multi-level attribute set.

(3) Bounding condition attributes to values and making attribute assignment tables.

The attribute assignment table is shown in Table 1.

Table 1. Table of conditional attribute assignment.

Table of Conditional Attribute Assignment	
C11 Supporting of the child for the elderly	strongly disagree = 1; uncertain = 2; totally agree = 3
C12 Decency of the new elderly care system	strongly disagree = 1; uncertain = 2; totally agree = 3
C13 Acceptance of non-traditional elderly care methods	strongly disagree = 1; uncertain = 2; totally agree = 3
C21 Gender	male = 1; female = 2;
C22 Age	60–65 years = 1; 66–70 years = 2; 71–75 years = 3; 76–80 years = 4; over 80 years old = 5
C23 Number of children	no children = 1; 1 = 2; 2–3 = 3; 3–5 = 4; more than 5 = 5
C24 Way of living	living alone = 1; living with spouse = 2; same generation in the second generation = 3; same generation in the third generation = 4
C25 Place of residence	town = 1; country = 2
C26 Degree of harmony in family relationships	very harmonious = 1; average = 2; less harmonious = 3
C27 Daily care	children = 1; self = 2; babysitter = 3; mutual care with his wife = 4; others (care facilities community neighbors relatives etc.) = 5
C28 Chronic history	no = 1; one = 2; two and more = 3
C31 The interest of smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C32 The fashion of smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C33 The wisdom of smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C41 Risk of smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C42 Personal privacy protection for smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C43 The improvement of quality of life by smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C44 The stability of smart elderly care equipment	strongly disagree = 1; uncertain = 2; totally agree = 3
C51 Degree of satisfaction of smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C52 Weaken level of the elderly care burden of smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C53 Timeliness of assistance for smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C61 The difficulty of using smart elderly care equipment	strongly disagree = 1; uncertain = 2; totally agree = 3
C62 Experience with smart elderly care devices and smartphone devices	strongly disagree = 1; uncertain = 2; totally agree = 3
C63 Correlation between education level and applicable smart elderly care services	primary school and below = 1; junior high school = 2; high school or technical school = 3; college = 4; undergraduate and above = 5
C71 Living expenses for smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C72 Pricing for smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3
C73 The relationship between income level and the adoption of smart elderly care services	below 1000 yuan = 1; 1001–3000 yuan = 2; 3001–5000 yuan = 3; 5001–8000 yuan = 4; Above 8000 yuan = 5
C81 The promotion of smart elderly care services by the government or the news media	strongly disagree = 1; uncertain = 2; totally agree = 3

Table 1. *Cont.*

Table of Conditional Attribute Assignment	
C82 People around you (family colleagues or friends) support the use of smart elderly care services for the elderly	strongly disagree = 1; uncertain = 2; totally agree = 3
C83 Sharing of information about the elderly's wisdom and elderly care by people around you (family colleagues or friends)	strongly disagree = 1; uncertain = 2; totally agree = 3
C84 The extent for the older to understand smart elderly care services	strongly disagree = 1; uncertain = 2; totally agree = 3

Then, the process of analyzing the importance of conditional attributes of smart elderly care services is shown in Figure 2. In the condition attribute importance analysis flow chart, the decision attribute corresponds to the first layer that is to adopt smart services of the multi-level attribute set the block diagram in Figure 1.

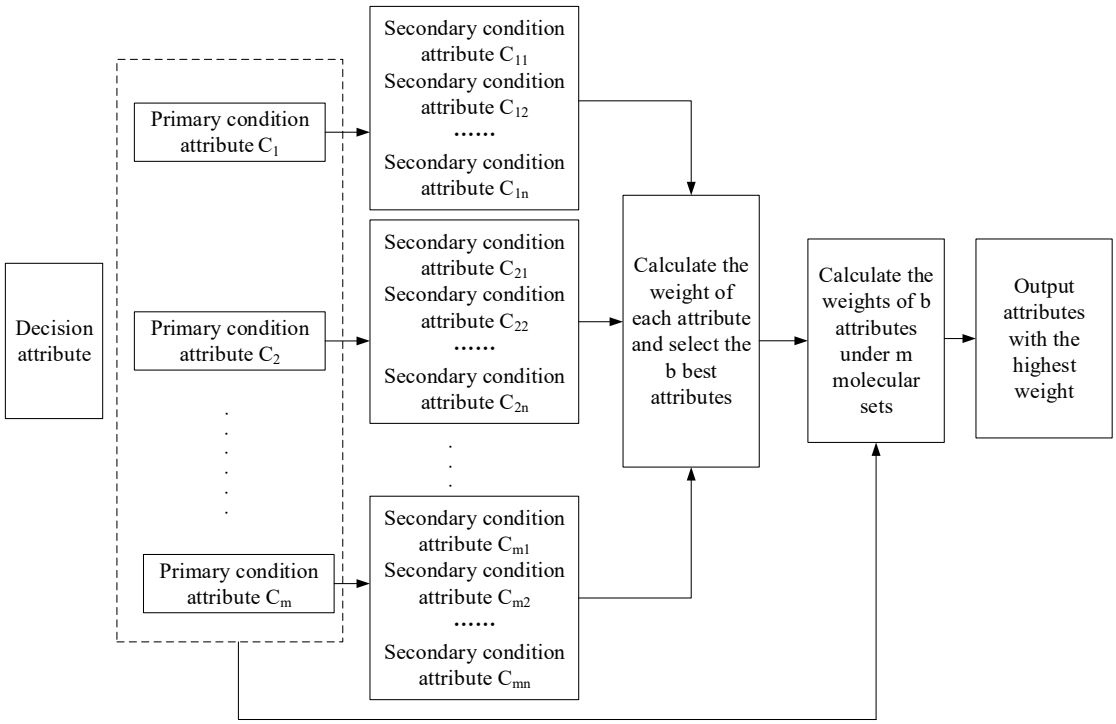

Figure 2. Flow chart of the importance of conditional attributes of smart elderly care services.

The study set the first-level condition attribute set as Cx = (x = 1 2 3 … and m), then the second-level condition attribute set under each first-level condition attribute in the set is Cx = (Cx1 Cx2 … Cxn). For instance, m = 8, where eight primary condition attributes are evaluated and analyzed for the adoption of smart elderly care services under several secondary condition attributes.

(4) Processing data.

The normalization equation is seen in Equation (9).

$$f(x_i) = \frac{x_i - x_{min}}{x_{max} - x_{min}} \tag{9}$$

The normalized data is shown in Table 2.

Table 2. Normalized data table.

Investigators	Condition Attribute Set														Decision Attribute Set		
	C1			C2		CX		C7		C8							
	C11	C12	C13	C1	…	C27	CXX	C71	C72	C73	C81	C82	C83	C84	D1	D2	D3
1	1	0	1	1		0		1	1	0.5	1	1	0	0.66667	1	0	1
2	1	0	0	0		0.33		1	1	0.5	0.5	1	1	0.66667	1	1	1
3	1	0	0	0		0		1	1	0.5	1	1	1	1	0.5	0.5	1
4	1	0.5	1	1		0		1	1	0.25	0.5	0	0	1	0	0	0
5	1	0	0	0		0.33		0.5	1	0.25	0	1	1	0.66667	1	1	1
6	0	0.5	1	0	…	0	…	0.5	1	0.5	0.5	0.5	0.5	1	0.5	0	0.5
7	1	0	0	0		0		1	1	0.75	1	1	1	1	0.5	1	1
8	1	1	0	1		0.67		1	1	0.75	0.5	1	0	0.66667	0.5	0	0
9	1	1	1	0		0		0.5	1	0.75	1	1	1	1	1	1	0.5
10	1	0	0	1		0		0	0	0	1	1	1	1	1	1	1
11	1	0	0	1		0.33		1	1	0.25	0	0.5	0	0.33333	0	0	0
…									…								
200	1	0	0	0		0.67		1	1	0.25	1	1	1	1	1	1	1
201	1	0	0	1	…	0	…	1	1	0.25	1	1	1	0.66667	1	1	1
202	0.5	0	0	0		1		1	1	0.25	1	1	1	0	1	1	0.5

(5) Setting parameters and finding the radius.

After the data is normalized, the neighborhood radius of the attribute subset is found. Then, the specific attribute value of each sample is the center of the circle and the space area is obtained with the radius of the neighborhood as the radius. The set of sample attribute values in this space is called the neighborhood $\delta(x_i)$.

The selection of neighborhood radius is a key factor affecting the result of attribute reduction. The equation for neighborhood radius is shown in Equation (10).

$$\delta(B_i) = \frac{S_{B_i}}{\lambda} \tag{10}$$

S_{B_i} is the standard deviation of the conditional attribute subset and λ is the characteristic parameter. In order to choose the optimal neighborhood radius, the value of feature parameter λ is very important. This study establishes a mathematical model for finding the best λ, which is shown in Equation (11).

$$f(\lambda) = \frac{\underline{\underline{N_B D}}}{N_B D} + \frac{Redset}{m} \tag{11}$$

Redset is the number of attribute reduction results; m is the number of all conditional attributes and m = 31; the parameter value is changed with a step size of 0.01. The corresponding results are obtained according to the above mathematical model and the relationship between the results, and λ is shown in Figure 3.

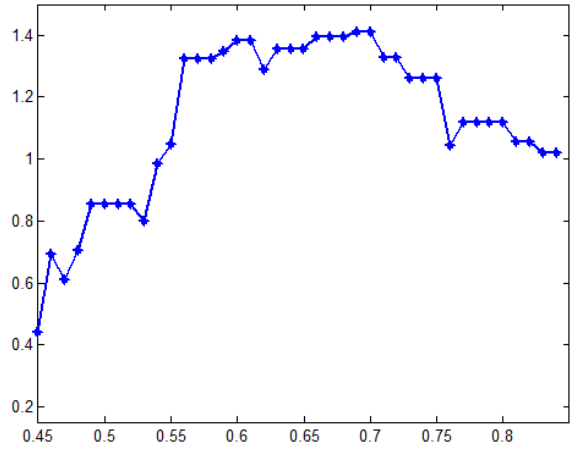

Figure 3. $f(\lambda)$ with different λ values.

Using Equation (11), the characteristic parameter λ is too large, and the neighborhood radius is too small leaded to attribute loss when the characteristic parameter λ is too small the neighborhood radius is too large, and the reduction result is too rough. Figure 3 showed that the experimental requirements are satisfied, when λ = 0.71 is selected. The neighborhood radius of the attribute subset is shown in Table 3.

(6) Dividing the universe and finding the lower approximation.

B is the subset of conditional attribute C that is $B \subset C$. Decision set D classifies U which is expressed as $U/D = \{X_1, X_2, \ldots, X_n\}$ to obtain the division results of the decision set. The division results are shown in Table 4.

Then, Equation (12) is used to find the lower approximation of the decision attribute on the attribute subset.

$$\underline{N_B D} = \bigcup_{i=1}^{N} \underline{N_B X_i} = Pos_B(D) \tag{12}$$

The result of $\underline{N_B}D$ is presented.

{4 5 6 7 8 9 15 $\overline{55}$ 10 12 13 25 61 165 17 19 20 24 39 95 18 26 29 30 31 32 33 34 36 37 41 43 46 47 48 49 51 53 56 57 59 128 62 63 64 78 65 66 67 68 69 71 73 75 76 80 81 84 86 88 90 91 92 93 96 97 99 101 102 103 104 105 106 108 109 110 111 112 193 115 116 117 119 120 121 122 123 124 126 130 131 154 133 137 138 140 141 142 143 135 145 148 146 147 157 150 151 152 153 155 156 160 161 163 164 166 167 171 174 175 176 178 179 180 113 181 182 58 184 185 188 191 192 194 195 196 197 198 200 202}.

Table 3. Condition attribute neighborhood radius table.

Condition Attribute Neighborhood Radius	Value	Condition Attribute Neighborhood Radius	Value	Condition Attribute Neighborhood Radius	Value
$\delta(C11)$	0.5639	$\delta(C32)$	0.5803	$\delta(C71)$	0.4426
$\delta(C12)$	0.5906	$\delta(C33)$	0.5388	$\delta(C72)$	0.4594
$\delta(C13)$	0.6034	$\delta(C41)$	0.5292	$\delta(C73)$	0.4036
$\delta(C21)$	0.7054	$\delta(C42)$	0.5313	$\delta(C81)$	0.4819
$\delta(C22)$	0.4654	$\delta(C43)$	0.5318	$\delta(C82)$	0.5844
$\delta(C23)$	0.3351	$\delta(C44)$	0.5172	$\delta(C83)$	0.5054
$\delta(C24)$	0.4102	$\delta(C51)$	0.4824	$\delta(C84)$	0.5537
$\delta(C25)$	0.3443	$\delta(C52)$	0.5362		
$\delta(C26)$	0.3301	$\delta(C53)$	0.5374		
$\delta(C27)$	0.4308	$\delta(C61)$	0.5607		
$\delta(C28)$	0.4630	$\delta(C62)$	0.5533		
$\delta(C31)$	0.5332	$\delta(C63)$	0.5113		

Table 4. The division results of the decision set.

U/D		Division of the Universe by Decision Attributes
Subsets	X1 (D = 1)	4 11 16 37 40 50 51 52 59 63 65 66 67 70 81 85 99 113 119 120 121 124 130 141 147 153 157 163 164 169 170 172 174 176 181
	X2 (D = 3)	3 6 7 8 14 17 19 21 22 23 27 30 33 35 44 56 58 69 71 73 77 80 86 88 91 94 98 111 117 125 127 133 135 139 144 145 146 148 150 156 160 161 168 173 179 184 185 188 198 199
	X3 (D = 5)	1 2 5 9 10 12 13 15 18 20 24 25 26 28 29 31 32 34 36 38 39 41 42 43 45 46 47 48 49 53 54 55 57 60 61 62 64 68 72 74 75 76 78 79 82 83 84 87 89 90 92 93 95 96 97 100 101 102 103 104 105 106 107 108 109 110 112 114 115 116 118 122 123 126 128 129 131 132 134 136 137 138 140 142 143 149 151 152 154 155 158 159 162 165 166 167 171 175 177 178 180 182 183 186 187 189 190 191 192 193 194 195 196 197 200 201 202

(7) Seeking dependence and importance of attribute subsets.

By using the lower approximation of the required decision attributes on the conditional attribute subset, the dependence of the decision attributes on the attribute subset is obtained according to Equation (13):

$$\gamma_B(D) = \frac{\left|Pos_B(D)\right|}{|U|} \tag{13}$$

Then,

$$\gamma_B(D) = \frac{\left|Pos_B(D)\right|}{|U|} = \frac{\left|\underline{N_B}D\right|}{|U|} = \frac{140}{202} = 0.6931$$

At this time, the condition attribute α is removed from the condition attribute subset B and then step 4 is performed to obtain the dependency at this time. $\gamma_{B-\{\alpha\}}(D) = \frac{\left|Pos_{B-\{\alpha\}}(D)\right|}{|U|}$. Each condition attribute is performed once until the test is completed.

Then, by using Equation (14) to find the importance of the attribute subset in the attribute set relative to the decision attribute and setting the corresponding lower limit of attribute importance to remove redundant elements.

$$Sig(a, B, D) = \gamma_B(D) - \gamma_{B-\{\alpha\}}(D) \tag{14}$$

The flowchart of calculating the importance of the conditional attribute subset to the decision attribute is shown in Figure 4.

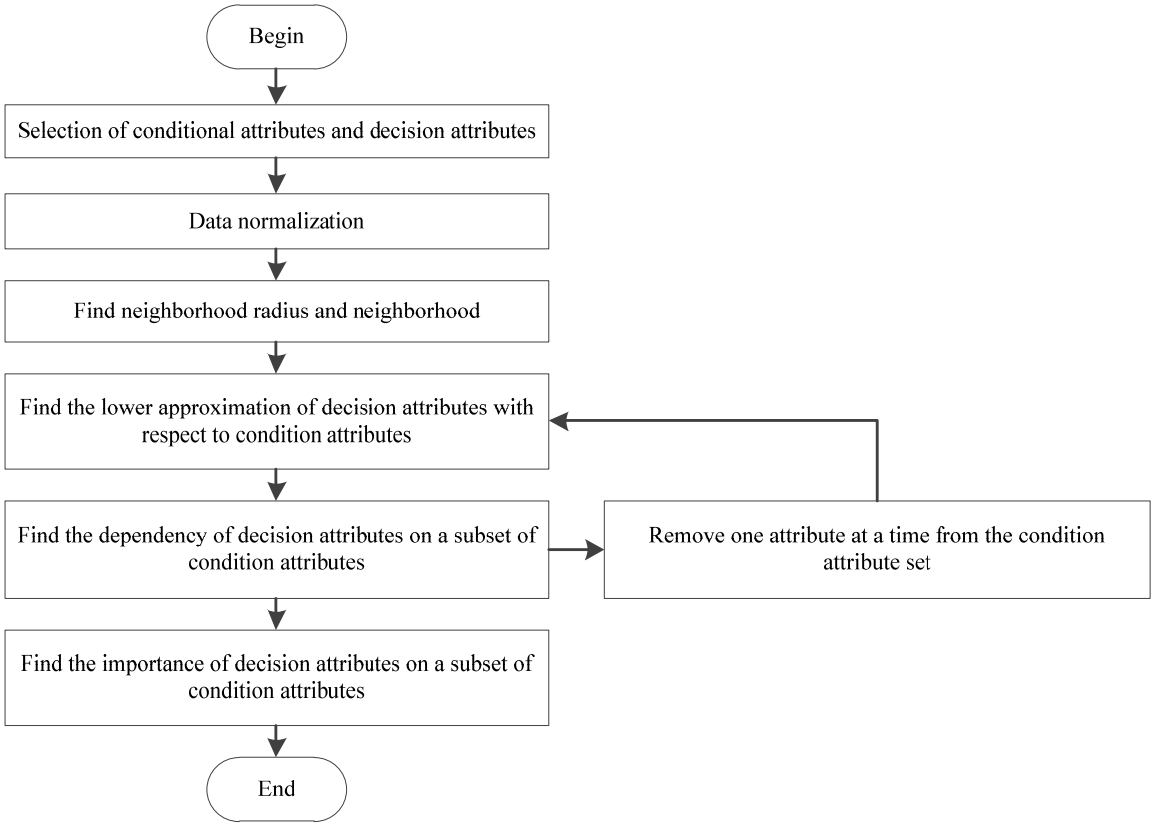

Figure 4. Flowchart of calculating the importance of conditional attribute subsets to decision attributes.

3.3. Verification of Neighborhood Rough Set Attribute Reduction Program

This study conducted an attribute reduction to verify the correctness of the neighborhood rough set attribute reduction program according to the information system given in Table 5.

Table 5. Information system.

	c_1	c_2	c_3	c_4	c_5	d
x_1	4.057	7.850	7.932	9.614	232.006	0
x_2	7.112	21.778	4.936	8.494	45.843	0
x_3	0.960	13.740	9.753	11.776	300.829	1
x_4	3.485	7.648	21.057	23.034	552.444	1
x_5	0.832	7.752	8.237	28.032	382.955	1

The neighborhood rough set attribute reduction program written by MATLAB programming software is used to attribute reduction the condition attributes in Table 5. The importance of each condition attribute in the table to the decision attribute is shown in Table 6. The importance of the condition attribute c_1 relative to the decision attribute is 1; the importance of the remaining condition attributes relative to the decision attribute is 0. The condition attribute reduction result is $\{c_1\}$ and is consistent with the condition attribute reduction result of the knowledge expression system. This indicates that the neighborhood rough set attribute reduction algorithm is effective.

Table 6. The importance of conditional attributes of a knowledge expression system.

Condition Attribute	Importance
c_1	1
c_2	0
c_3	0
c_4	0
c_5	0

4. Results

The attributes take and adopt smart elderly care service taken as the decision attribute, and the rest are conditional attributes. The condition attributes are mainly divided into eight primary condition attributes and 31 secondary condition attributes. Primary condition attributes (1) the concept of elderly care; (2) the condition of family and health; (3) using attitude; (4) trust perception; (5) useful perception; (6) easy-to-use perception; (7) cost perception; and (8) subjective norms. The secondary attributes are all attributes in the original questionnaire. By using MATLAB programming software, the input condition attributes are reduced by using the verified neighborhood rough set attribute reduction program, and the attribute reduction results are obtained. The reduction results are analyzed below.

4.1. Analysis of the Importance of Primary and Secondary Condition Attributes

The neighborhood rough set theory is used to reduce the attributes of the secondary conditional attributes of which were calculated the importance to the decision attributes, and further analyze the influencing attributes of the elderly's demand for smart elderly care services. The preliminary results of attribute reduction by neighborhood rough set are shown in Table 7.

Table 7. Importance of primary and secondary symmetric condition attributes.

Primary Condition Attribute	Secondary Condition Attribute	Importance of Secondary Condition Attribute
C1 The concept of elderly care 0.0589	C11 Supporting of the child for the elderly	0.0589
	C12 Decency of the new elderly care system	0
	C13 Acceptance of non-traditional elderly care methods	0
C2 The condition of family and health 0.5571	C21 Gender	0.23529
	C22 Age	0
	C23 Number of children	0
	C24 Way of living	0.058824
	C25 Place of residence	0.088235
	C26 Degree of harmony in family relationships	0.088235
	C27 Daily care	0.029412
	C28 Chronic history	0.058824
C3 Using attitude 0	C31 The interest of smart elderly care services	0
	C32 The fashion of smart elderly care services	0
	C33 The wisdom of smart elderly care services	0
C4Trust perception 0	C41 Risk of smart elderly care services	0
	C42 Personal privacy protection for smart elderly care services	0
	C43 The improvement of quality of life by smart elderly care services	0
	C44 The stability of smart elderly care equipment	0

Table 7. *Cont.*

Primary Condition Attribute	Secondary Condition Attribute	Importance of Secondary Condition Attribute
C5 Useful perception 0	C51 Degree of satisfaction of smart elderly care services	0
	C52 Weaken level of the elderly care burden of smart elderly care services	0
	C53 Timeliness of assistance for smart elderly care services	0
C6 Ease-of-use perception 0	C61 The difficulty of using smart elderly care equipment	0
	C62 Experience with smart elderly care devices and smartphone devices	0
	C63 Correlation between education level and applicable smart elderly care services	0
C7 Cost perception 0.2660	C71 Living expenses for smart elderly care services	0.20588
	C72 Pricing for smart elderly care services	0
	C73 The relationship between income level and the adoption of smart elderly care services	0.058824
C8 Subjective norms 0.1180	C81 The promotion of smart elderly care services by the government or the news media	0.058824
	C82 People around you (family colleagues or friends) support the use of smart elderly care services for the elderly	0
	C83 Sharing of information about the elderly's wisdom and elderly care by people around you (family colleagues or friends)	0
	C84 The extent for the older to understand smart elderly care services	0.058824

Table 7 presented the above-mentioned 31 secondary condition attributes have different importance to the decision attributes and the importance are all between 0 and 0.23529. The condition attribute of gender is the most important with the importance of 0.23529, indicating that gender is the main factor affecting the acceptance of smart elderly care services. The condition attribute of living expenses for smart service is second in importance to decision attribute, and its importance is 0.20588. There are conditional attributes, including children's support for the elderly living style place of residence harmony of family relationships chronic medical history income level and adoption of smart service and efforts by the government or the news media on smart elderly care service whose importance is between 0.05 and 0.1. This indicates that the conditional attributes have a slight impact on whether to adopt smart services. The importance of the conditional attribute of daily care which indicating this condition attribute has little effect on whether or not to adopt smart elderly care is between 0 and 0.05. In addition, these conditional attributes, such as the decency of novel elderly care, acceptance of non-traditional elderly care methods, age number of children, the interest of smart services, the fashion of smart e-service and the difficulty of using smart services whose importance of conditional attributes to decision attribute is 0, indicating the influence of conditional attributes on the adoption of smart elderly service is relatively small compared to other conditional attributes and could be ignored.

4.2. Conditional Attribute Reduction Results and Verification

The multi-level attribute set block diagram is for smart elderly care acceptance, and the importance of the secondary condition attributes obtained in Table 7 The importance of the primary condition attributes to the decision attributes is obtained. The secondary condition attribute with the importance value of 0 is a redundant condition attribute, which is deleted in the reduction process. The reduction results are shown in Tables 8 and 9.

Table 8. Result of conditional attribute reduction.

Primary Condition Attribute	Secondary Condition Attribute	Importance of Secondary Condition Attribute
C1 The concept of elderly care 0.0589	C11 Supporting of the child for the elderly	0.0589
	C12 Decency of the novel elderly care system	0
	C13 Acceptance of non-traditional elderly care methods	0
C2 The condition of family and health 0.5571	C21 Gender	0.23529
	C24 Way of living	0.058824
	C25 Place of residence	0.088235
	C26 Degree of harmony in family relationships	0.088235
	C27 Daily care	0.029412
	C28 Chronic history	0.058824
C7Cost perception 0.2660	C71 Living expenses for smart elderly care services	0.20588
	C72 Pricing for smart elderly care services	0
	C73 The relationship between income level and the adoption of smart elderly care services	0.058824
C8 Subjective norms 0.1180	C81 The promotion of smart elderly care services by the government or the news media	0.058824
	C84 The extent for the older to understand smart elderly care services	0.058824

Table 9. The comparison of the classification precision of the symmetric decision attribute and the importance of the condition attribute.

Condition Attribute	Classification Precision α_1	Classification Precision α_2	Changes in Classification Precision $\Delta\alpha=\alpha_1-\alpha_2$	The Importance of the Condition Attribute
C11	0.9752	0.9653	0.0099	0.0589
C12		0.9752	0	0
C13		0.9752	0	0
C21		0.9356	0.0396	0.23529
C22		0.9752	0	0
C23		0.9752	0	0
C24		0.9653	0.0099	0.058824
C25		0.9604	0.0148	0.088235
C26		0.9604	0.0148	0.088235
C27		0.9653	0.0099	0.029412
C28		0.9604	0.0148	0.058824
C31		0.9752	0	0
C32		0.9752	0	0
C33		0.9752	0	0
C41		0.9752	0	0
C42		0.9752	0	0
C43		0.9752	0	0
C44		0.9752	0	0
C51		0.9752	0	0
C52		0.9752	0	0
C53		0.9752	0	0
C61		0.9752	0	0
C62		0.9752	0	0
C63		0.9752	0	0
C71		0.9406	0.0346	0.20588
C72		0.9752	0	0
C73		0.9356	0.0396	0.058824
C81		0.9653	0.0099	0.058824
C82		0.9752	0	0
C83		0.9752	0	0
C84		0.9653	0.0099	0.058824

Table 8 presented the primary condition attribute of the condition of family and health is the most important with an importance of 0.5571. The importance of the elderly's cost perception is 0.2660; the subjective norm of the elderly is 0.1180. The importance of the concept of elderly care is 0.0589. This result showed that the acceptance of smart elderly care by the elderly is largely affected by the condition of family and health.

This study calculates the change of classification precision of a certain condition attribute under the condition of existence and non-existence and compares the change with the importance of condition attributes in order to verify the accuracy of the attribute, reduction results based on the importance of condition attributes to decision attribute. The comparison of the classification precision of the decision attribute and the importance of the condition attribute were shown in Table 9 and Figure 5.

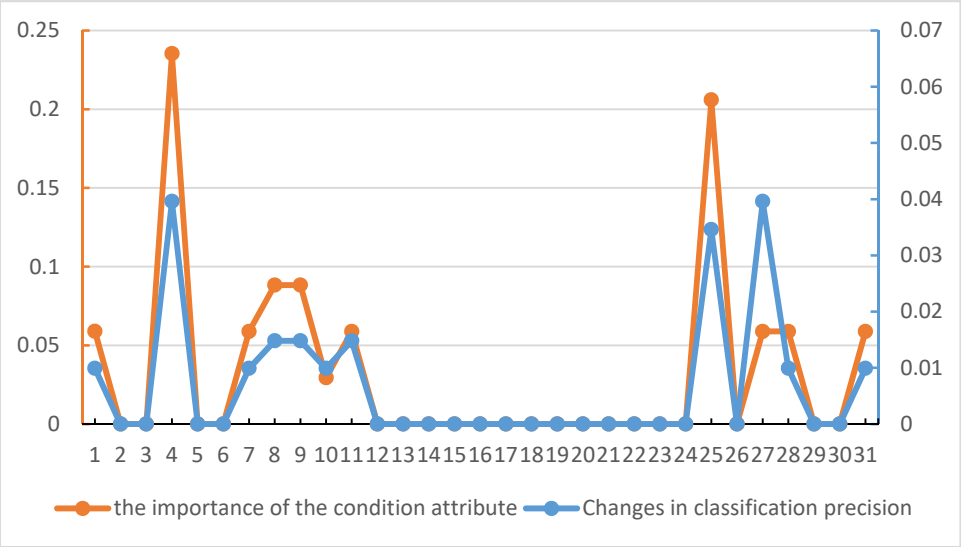

Figure 5. The comparison of the classification precision of the decision attributes and the importance of the condition attributes.

Figure 5 showed a condition attribute with greater importance when it is removed. The classification accuracy of the decision attribute also changes greatly; on the contrary, for a condition attribute with less importance. When it is removed, the classification precision of the decision attribute changes little; if the condition attribute is a redundant attribute the existence or removal of this condition attribute does not affect the classification precision of the decision attribute.

The neighborhood rough set attribute reduction program was used in this study which runs by MATLAB programming software and verifies the reduction results of condition attributes and the importance of condition attributes. This study could determine which attributes play a key role in the adoption of smart elderly care services which have little effect and minimal influence, and which is ignored. The results provide a valuable reference for the future development of smart elderly care services.

4.3. Analysis of Symmetric Attributes in Adopting Smart Elderly Care Based on the Importance of Condition Attributes

The importance values of the secondary condition attributes, which are under each primary condition attribute, are shown in Tables 10–13.

Table 10 presented the importance of the elderly's gender in adopting smart elderly care service is 0.23529. There are differences between men and women in their attitudes towards elderly care. Among the total number of people surveyed, 97 are men, and 105 are women. Among men, 45 men made it clear that they are willing to adopt smart service accounting for about 46.39% of the total

number of men, and 34 men did not indicate their willingness to adopt smart service, and the remaining express reluctance to adopt smart elderly are services. Among women, 37 women made it clear that they are willing to adopt smart elderly service accounting for about 35.24% of the total number of women, and 38 women did not indicate their willingness to adopt smart service accounting for about 36.19%. The remaining express is reluctant to adopt smart elderly care service. The data shows that compared to female seniors, 46.39% of men are more willing to adopt smart services, while women only account for 35.24%. This shows that men are more likely to adopt smart service. Meanwhile, a total of 82 people in the survey expressed their willingness to adopt smart elderly care services accounting for about 40.59% of the total number of people, while 48 elderly people who clearly expressed reluctance to adopt smart services accounted for 23.76%. The majority of the elderly who have a clear attitude is willing to adopt smart service, and the proportion of males is higher than that of females. The elderly who have not expressed their attitudes may adopt smart elderly care services in the future.

Table 10. Importance of secondary condition attribute in the condition of family and health.

Secondary Condition Attribute in the Condition of Family and Health	Importance
Gender	0.23529
Place of residence	0.088235
Degree of harmony in family relationships	0.088235
Way of living	0.058824
Chronic medical history	0.058824
Daily care	0.029412

Table 11. Importance of secondary condition attribute in cost perception.

Secondary Condition Attribute in Cost Perception	Importance
Living expenses for smart elderly care services	0.20588
The relationship between income level and the adoption of Smart elderly care services	0.058824
Pricing for smart elderly care services	0

Table 12. Importance of secondary condition attribute in subjective norms.

Secondary Condition Attribute in Subjective Norms	Importance
The extent for the older to understand smart elderly care services.	0.058824
The promotion of smart elderly care services by the government or the news media.	0.058824
People around you support the use of smart elderly care Services for the elderly.	0
Sharing of information about the wisdom of elderly people, and elderly care by people around you.	0

Table 13. Importance of secondary condition attribute in the concept of elderly care.

Secondary Condition Attribute in the Concept of Elderly Care	Importance
Supporting of the child for the elderly	0.0589
Decency of the new elderly care system	0
Acceptance of non-traditional elderly care methods	0

The importance of the elderly's place of residence for the adoption of smart elderly care service is 0.088235. The questionnaire divides the place of residence into town and village, and about 65% of the elderly live in town. Among the elderly living in town, 54 people made it clear that they are willing to adopt smart elderly care service accounting for about 40.91% of urban elderly people, and 43 people did not indicate their willingness to adopt smart service accounting for about 32.58% of urban elderly people. The remaining people made it clear that they would not adopt smart elderly care service. Among the elderly living in rural areas, 28 people made it clear that they are willing to adopt smart service accounting for about 40% of rural elderly people, and 29 people did not indicate their willingness to adopt smart service accounting for about 41.43% of rural elderly. The remaining

people made it clear that they would not adopt smart elderly care service. The proportion of elderly people who live in rural areas is slightly higher than that in urban areas.

The importance of the harmony of the elderly's family relationship to the adoption of smart elderly care service is 0.088235. A harmonious family atmosphere is an important guarantee for improving the quality of life of the elderly. The family is an important place for the elderly to live, and the elderly have a relatively higher degree of attention and dependence on the family. The harmonious family atmosphere can make the elderly feel the warmth and care of the family and relieve the spiritual emptiness and loneliness. The disharmonious family relationship will make the elderly feel worried and anxious compared with the harmonious family relationship. When the elderly's spiritual life is not satisfied to seek life and spiritual comfort, and they are more willing to adopt smart elderly care service.

Chronic disease in the elderly belongs to the health status of the elderly. The importance of this condition attribute is 0.058824. The harm of chronic diseases is mainly caused by damage to the brain heart kidney and other important organs which can easily cause disability. The elderly's ability to work and quality of life and the medical expenses are extremely expensive, increasing the economic burden on society and families. Although medical standards and medical services have improved, and the comprehensive prevention and control of chronic diseases have been gradually strengthened, so the situation of prevention and control is still grim. The number of deaths caused by chronic diseases has accounted for 86.6% of the total deaths in the country. Chronic diseases have become the main worry and anxiety of the elderly and affect the elderly's judgment on whether to adopt smart elderly care services.

The attribute of daily care for the elderly belongs to the condition of family and health. The importance of this influencing factor is 0.029412. Elderly people who live alone, live with their children, live with their wives, take care of a nanny or live in an elderly care institution also have different attitudes towards adopting smart elderly care services. At present, there are more and more elderly people in society. It is a good choice to adopt smart elderly care for these alone. For the seniors accompanied by others, their family emotional life is relatively satisfactory, so they do not need urgently to support the smart services. The elderly population is often cared for by relatives, and the emotional life is richer accordingly, there is no urgent need for smart elderly care. The elderly who live in the old-age care institutions which rely on foreign objects to provide for the elderly, so the smart service belongs to this method to a certain extent. The elderly who live alone and in the elderly care institutions are more willing to accept the services compared with the elderly who live with their children and with their husbands.

Table 11 showed the importance of cost perception for the elderly accounted for 0.2660. Cost perception includes the living expenses of smart elderly care services the pricing of smart services the relationship between income level and the adoption of smart elderly care services. The importance of living expenses for smart elderly care services which is the second most important of all condition attributes is 0.20588 and has a greater impact on whether to adopt smart services. The data reflects concerns about the impact on living expenses when smart elderly care services are adopted. The response results of this data are consistent with human nature. People's quality of life and living expenses are inseparable. If smart elderly care services account for a large part of living expenses, other living expenses will inevitably be reduced, which may have a negative impact on the quality of life. The larger the living expenses caused by the adoption of smart services and more reluctant the elderly are to adopt smart elderly care services.

The importance of the relationship between income level and the adoption of smart elderly care services is 0.058824. The level of income determines the consumption-ability of people to a certain extent. Their income sources mainly come from pensions and wealth accumulation when most people enter old age. Generally, there are no other income sources. The monthly income of the elderly also determines whether the elderly can afford the spending on smart service and adopt it.

Table 12 indicated the importance of adopting smart elderly care services of the subjective norms of the elderly is 0.1180. Subjective norms include: The government or news media's promotion of smart elderly care services people around you (family and colleagues or friends) support the use of smart services for the elderly the extent for the older to understand smart services. Among them, the extent for the older to understand smart services of elderly care is 0.058824. People are subconsciously awed or unwilling to try unknown things, and they lack trust. When the elderly population has a certain understanding about a smart care service for elderly, according to their own needs, they decide to adopt these services.

For decision attributes, the importance of the conditional attribute of the government or the news media's propaganda of smart elderly care services is 0.058824. Publicity and introduction by the government or news media of smart elderly care services can increase the elderly's trust and understanding of smart services and enable the elderly to better assess the fit of smart services to themselves. In addition, the ability of the elderly to receive information is gradually diminishing with age, and most of the information they receive comes from television and news media sharing. The recommendations of government or media have a strong influence on the judgment of the elderly make them more trusted. Therefore, this condition attribute affects, to a certain extent, whether elderly people adopt smart services.

Table 13 indicated the importance of the concept of elderly care to the adoption of smart elderly care service is 0.0589. The concept of elderly care includes decency of the new elderly care system, support of the child for the elderly and acceptance of non-traditional elderly care methods. Among them, the condition attribute of support of the child for the elderly is 0.0589, which is also important to the decision attribute. The adoption of smart elderly care service is also affected by the traditional concept of elderly care. They are more willing than their child cares for them. For the elderly who have children to support, they do not think they need any extra way to support the elderly. The elderly population, who have more traditional ideas, are more reluctant to adopt smart services than the elderly with non-traditional ideas.

5. Implications

The study chooses whether to adopt smart elderly care as symmetric decision attribute with other attributes in the questionnaire as condition attributes. The attribute reduction of conditional attributes is carried out using neighborhood rough set theory. This study presented that different the importance of condition attributes for decision attribute. Moreover, the conditional attributes set whether to adopt smart elderly care service or not is established. This study provides a better reference value for the future development of the smart elderly care service.

The main scientific contributions of this study are as follows.

(1) Building a multi-level attribute set block diagram to forecast the main demand attributes of smart elderly care service. In the case of big data, there are many attributes which affect the acceptance of smart elderly care. To conveniently assign the importance of condition attribute relative to decision attributes after attribute reduction and the analysis of data conditional attributes are classified and divided before attribute reduction. In this way, the reduction algorithm can process the data more efficiently and accurately.

(2) Reducing the influence attributes of wisdom endowment acceptability by using neighborhood rough sets. To better evaluate the demand attributes of smart elderly care. This study adopts the neighborhood rough set to carry out attribute reduction for multiple conditional attributes. The purpose is to eliminate redundant attributes and extract the main influencing attributes of the demand for smart elderly care. This study provides a valuable reference for the development of smart elderly care service in the future.

(3) Building the mathematical model to find the best λ. The rough set of the neighborhood is used to reduce the attributes of the condition attributes to get more accurate results of the attribute reduction. Furthermore, the selection of the neighborhood radius is important. Therefore, if the

optimal radius is selected, the λ value must be best. This study has been established to calculate the mathematical model of optimal λ. Firstly, the step size is 0.01 to change the parameter λ value getting different λ values of $f(\lambda)$. Secondly, it has been analyzed the effect of λ smaller or larger value on the attribute reduction result of the neighborhood rough set. This study is good to select the optimal λ value and get a more objective attribute reduction result. This λ value guarantees the symmetry of reduction results and classification accuracy, and gets a more objective attribute reduction result.

(4) Verifying the result of attribute reduction by sensitivity analysis. This study used the neighborhood rough set theory to obtain the reduction results. Based on the importance of the conditional attribute to the decision attribute, the sensitivity analysis of the conditional attribute can verify whether the reduction result of the attribute is correct. The methods of attribute reduction and verification of reduction results used to make it as a valuable study direction to find knowledge directly from MSIS without losing information and problems, such as evaluating indoor air quality level of buildings is solved [30,54]. Neighborhood rough set was used to reduce conditional attributes and verify by the method of sensitivity analysis. This study provides a reference for future problems to reduce attribute and verification of attribute reduction results.

(5) Attribute reduction results by using neighborhood rough set, are of significance for the smart the elderly care service and the future development of management. This study has been combined with the integration of smart elderly theory and practice in the context of Chinese characteristics. In addition, this study makes a comprehensive analysis of these influencing attributes and promotes the reform and development of intelligent elderly care. The results present gender and living expenses for smart services are two condition attributes that play a key role in the adoption of smart elderly care service. In addition, the condition attribute of daily care is also an important factor to consider.

(6) The results show that the condition attribute of decency of the new elderly care system also has a certain impact on the adoption of smart services. Contemporary society needs to take the essence and discard the dross of traditional ideas change the traditional ideas, such as raising children for old age and publicize new smart services with the progress of society, and the development of intelligent technology. In addition, the condition attribute of a place of residence has a certain impact on the adoption of smart services. Elderly people living in rural areas are more likely to adopt smart services.

6. Conclusions

Smart elderly care service has become the main study direction in recent years. This study analyzes the influencing factors of adopting smart services in China and presents a clearer understanding of the needs of the seniors and the understanding of smart elderly care. However, few studies have been able to explain the main symmetric attributes that influence the acceptance of smart elderly care. Firstly, set whether to adopt smart elderly care service as the decision attribute and the remaining attributes in the questionnaire as the condition attribute. Secondly, this study is explored the precision influencing attributes all the 31 secondary condition attributes are divided into eight primary condition attributes, such as elderly care concept, cost perception, family and health condition. Thirdly, the attribute reduction of neighborhood rough set is used to obtain the conditional attribute set with significant influence on symmetric decision attribute, and the reduction result is verified by the method of sensitivity analysis. The main contribution is to analyze the importance of attributes influencing the acceptability of smart elderly care service and show how to upgrade the future management of this service.

The study finds the symmetric attributes influencing the acceptance of smart elderly care could be divided into eight aspects, such as the concept of elderly care, the condition of family and health, Using attitude, Trust perception, Useful perception, Ease-of-use perception, Cost perception, and Subjective norms. The condition of family and health, cost perception are the main attributes that

affect the acceptance of smart elderly care service. In the condition of family and health attributes, gender plays the most important conditional attribute in decision-making attributes. Living expenses are the second most important attribute to decision-making. The secondary condition attributes such as the decency of the novel elderly care system, the relationship between income level and the adoption of smart elderly care services and chronic history also have a certain degree of influence on the adoption of smart care.

This study conducted an attribute reduction for all condition attributes and scientifically verified the reduction results. This study analyzes the attributes affecting the acceptability of smart elderly care based on the concept of the importance of condition attributes to decision attribute. The market is getting more and more global with the development of technology. As a consequence, the main contribution to develop smart elderly care service is fit for Chinese seniors based on the national conditions and the elderly lifestyle. The reduction results of condition attribute obtained and the different importance of condition attribute to decision attribute provides a more accurate direction for future smart elderly care service and make a more specific plan in the field of smart elderly care.

This study puts forward the following aspects for reference to improve the acceptance of smart elderly care service: (1) Old-age care institutions or relevant departments provide cost-effective smart elderly care; (2) explaining the new concept of smart elderly care to the elderly in a large range of cities and villages across in China intensify the publicity of smart elderly care services so that the elderly can learn about smart elderly care from multiple channels and have a deeper understanding of smart elderly care; (3) old-age care institutions or relevant departments combines old intelligent network technology services with warm human feelings to provide the seniors with a warm emotional and comfortable humanized smart elderly care space; and (4) this study establishes a comprehensive and multi-level smart elderly care system to provide the elderly seniors with necessary, low-cost, safe and reliable smart services.

This study has some limitations. The neighborhood rough set theory is used to reduce the condition attributes that affects the acceptability of smart elderly care. By reducing many irrelevant attributes to build a condition attribute set with a high degree of importance, the results are more accurate than the actual experience and knowledge of experts, but it also has some disadvantages: (1) The formulation of condition attributes depends on human cognition of society and is subjective; (2) biased judgment of reduction result will affect the final result; (3) this study is unable to judge the condition symmetric attributes that are not involved. In a future study, it is necessary to consider the issue of smart elderly care from multiple aspects and perspectives. Meanwhile, the detailed description of smart elderly care is still less. The future study needs to focus on specific smart elderly care service platform or equipment to continuously enrich the research topics of smart services.

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