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Study on the User Segmentation Method Based on the Combination of User-FRT Matrix and HAC in the View of the Product Usage Scenarios

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Abstract:

The importance of user need is widely known in product design stage. However, how to build up a clear correspondence between a certain type of user and a product function is still an issue. In order to solve this problem, this paper proposes a user segmentation method based on product usage scenarios. By clustering the usage situation of product function modules, product usage scenarios that meet different user demand levels can be obtained and the user segmentation is thereby achieved. In this paper, the Kano model is first applied to determine customers' functional requirements to construct the User-FRT matrix and acquire the functional performance index. The R-type clustering is then used to cluster the numerous functional performance indexes in order to reduce the amount of computation. Finally, the user segmentation is achieved by using hierarchical agglomerative clustering method in accordance with the simplified indicators. A case study of agricultural UAVs is implemented to verify the proposed method.

Keywords*: User segmentation; Product usage scenarios; User-FRT matrix, HAC.*

Ⅰ. INTRODUCTION

There is an obvious tendency that customers' requirements for products and services are becoming personalized. The common and non-differentiated products and services that used provided by manufacturers are no longer meeting the needs of users, and cause the waste of resources as well. Meanwhile, manufacturing enterprises have also been transformed from product-centered to customer-centered. Satisfying customers is always the first and crucial way for manufacturing companies to be more competitive. In this context, segmenting customers to better meet their personalized requirements is an effective method to overcome the challenge. The personalized products and services, which can get the maximum satisfaction, can then be designed and produced based on the results of user segmentation.

In reality, every company will segment their target customers into many different categories with different requirements. The researches on user segmentation are primarily based on the population statistics, such as age, profession, gender, consumption habits and so on. Philip Kotler [1] suggested that there were segmented markets in all industries, and the characteristics of each segmented market are different, but consumers have similar behaviors and consistent demands. Changqing Hu et al. [2] took the user segmentation of electric power enterprises as an example, defined the weight of classification indicators by using entropy method and principal component analysis method, and then used k-means algorithm to subdivide customers. Ling Zhu et al [3] used AI technology to model and analyze the insurance marketing field, and concluded that the use of AI technology can effectively improve the level of user segmentation of enterprises. Zheng Qian et al [4] taking a foreign-funded medical company as an example, combined customer segmentation with customer value using data mining algorithms and clustering algorithms, and optimized the company's customer segmentation plan. However, the functions of modern products are multifarious. The distinctions of customers are far more beyond the traditional criterion built by population statistics. Actually, the current customer requirements mainly depend on the personal usage scenarios and have no relationship with age and gender. The traditional is no longer suitable for modern products. Therefore, this paper proposed a division method of user segmentation based on usage scenarios.

Accurate analysis of customer demand is a crucial step in product design. Violante et al. [5] proposed the methods of extracting user demand based on Kano model and user satisfaction degree to provide data for subsequent product design. Ma et al. [6] used comprehensive multidisciplinary demand modeling method to obtain user demand. Wang et al. [7] obtained user requirements through gray rough model and transformed them into relevant features. Zheng Wang et al [8] proposed a performance requirement inference method based on operation data to avoid the shortcomings of traditional user demand analysis methods, which are subjective and unquantifiable. Sun Bing et al. [9] made use of online comments to distinguish product demand preference and subdivide customers for four popular mobile phones. Wanting Tong et al [10] uses the optimized k-means algorithm to cluster Unicom's personal mobile phone users into high-value user groups, growth-type user groups, loyal user groups and general-value user groups, and provides different services for different types of users program to complete user segmentation. Hui Liu [11] used the hierarchical clustering method to divide the people who use Weibo into three categories to achieve user segmentation.

By analyzing the existing user segmentation studies, k-means clustering algorithm is most common method used for user segmentation. However, there are some obvious limitations for this method. For instance, the selection of K value in the K-means clustering algorithm will affect the results, and the determination of K value is also difficult. Therefore, this paper chooses the hierarchical clustering method with R-type clustering.

Ⅱ. STUDY FRAMEWORK

In this paper, the division of users is considered from the perspective of different product usage scenarios. The research framework of this paper is illustrated in Figure 1 below.

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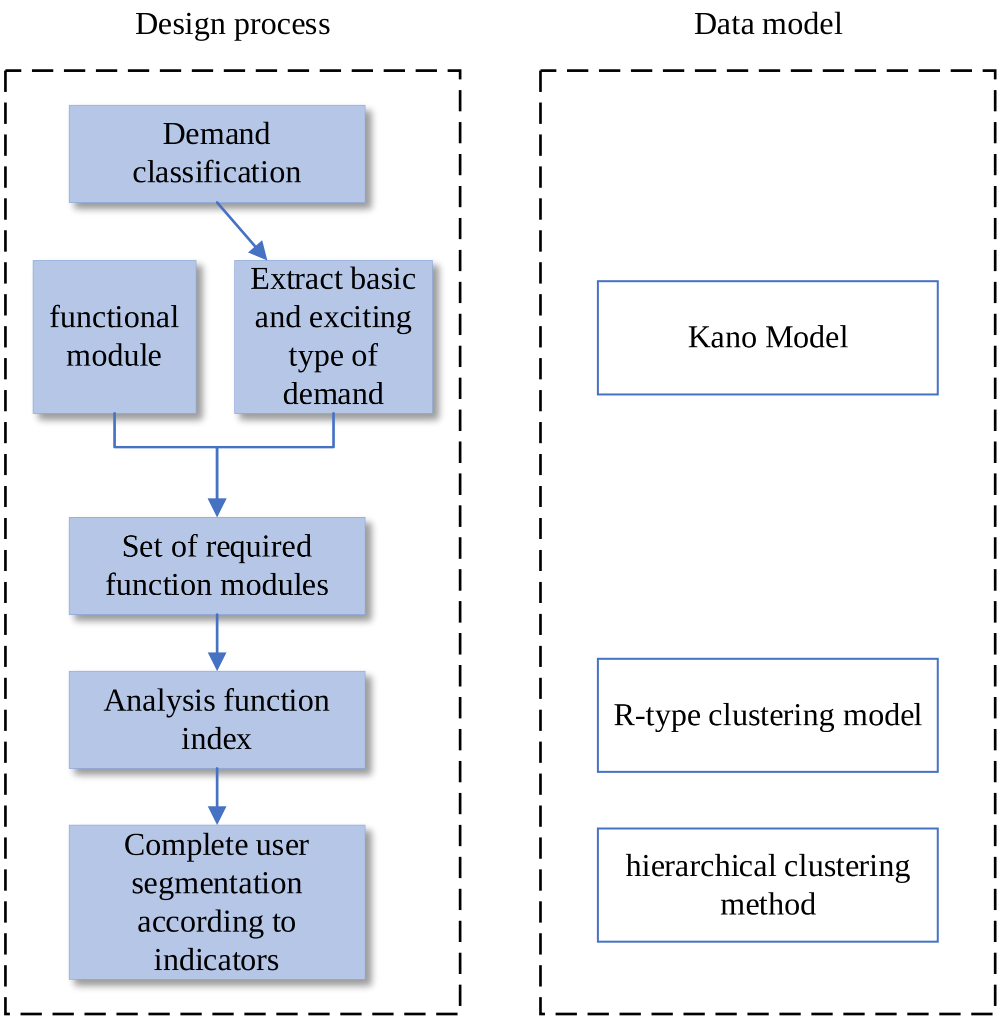

Fig 1: Research frame diagram

As shown in Fig.1, the end user's demands will be extracted from the data gained from the questionnaire and operation records by using Kano model. After clustering the customer requirements, the usage scenarios can then be summarized. In order to reduce the data processing difficulty and shorten the processing time, the R-type clustering model is used in this paper to cluster indicators to simplify the data processing. Finally, the improved hierarchical clustering method is applied to achieve user segmentation.

Ⅲ. MODEL CONSTRUCTION OF USER SEGMENTATION BASED ON THE PRODUCT USAGE SCENARIOS

In this paper, the product usage scenario is evaluated by the users' functional requirements. The users have the same usage parameters to the certain functional module, such as operating frequency, service time and so on are considered in the same usage scenarios.

3.1 Determination of User Functional Requirements Based on Kano Model

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The user functional requirements can be determined based on user functional satisfaction by using Kano model. This paper adopts the method of questionnaire to obtain the user's functional satisfaction, which mainly includes three steps.

(1) Acquire Data

Use the Kano model to design a questionnaire to ask forward and reverse questions about a certain functional performance of the product. The type of quality element of the functional performance index is judged by the degree of satisfaction of the user's answer to the function performance index. The forward problem describes the function that the customers should be satisfied with, and the reverse problem is the opposite. One particular function is judged with five components: satisfied, relatively satisfied, no influence, relatively dissatisfied, and dissatisfied. The quality factor is the expression of customer satisfaction. The Kano model defines five types of needs, in which A is the exciting (charismatic) type of demand corresponding to the exciting quality element, M is the basic (must-have) type of demand corresponding to the necessary quality element, I is the indifference type of demand corresponding to the indifference quality element, R is the reverse (reverse) demand corresponds to the reverse quality element, and O is the expected (willing) demand corresponding to the willing quality element. TABLE Ⅰ is the table of quality element types, where Q means in doubt.

TABLE Ⅰ. Quality element type table

CUSTOMER NEED		**THE REVERSE PROBLEM**				
		SATISFIED	**RELATIVELY SATISFIED**	**NO INFLUENCE**	**RELATIVELY DISSATISFIED**	**DISSATISFIED**
THE FORWARD PROBLEM	SATISFIED	Q	A	A	A	O
	RELATIVELY SATISFIED	R	I	I	I	M
	NO INFLUENCE	R	I	I	I	M
	RELATIVELY DISSATISFIED	R	I	I	I	M
	DISSATISFIED	R	R	R	R	Q

(2) Build User-FRT (functional requirement type, FRT) matrix

Through organizing and analyzing the data obtained from the questionnaire, the construction of a User-FRT matrix is completed with users as row vectors and functional requirement indexes as column vectors. As shown in TABLE Ⅱ.

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TABLE Ⅱ. User-FRT matrix

USERS \ NEED	NEED Ⅰ	NEED Ⅱ	NEED Ⅲ	NEEDⅣ	……	NEED m
1	A	R	M	I	……	I
2	I	A	M	I	……	A
……	……	……	……	……	……	……
n	A	R	I	I	……	A
Summary：The number of A	a_1	a_2	a_3	a_4		a_m
The number of O	o_1	o_2	o_3	o_4		o_m
The number of M	m_1	m_2	m_3	m_4		m_m
The number of I	i_1	i_2	i_3	i_4		i_m

According to Table II and Formula (1) – (4), A_i, O_i, M_i, and I_i were calculated respectively.

$$A_i = \frac{a_m}{n} \tag{1}$$

$$O_i = \frac{o_m}{n} \tag{2}$$

$$M_i = \frac{m_m}{n} \tag{3}$$

$$I_i = \frac{i_m}{n} \tag{4}$$

Then, formula (5) and formula (6) are used to calculate the satisfaction of each functional requirement index.

$$S_i = \frac{A_i + O_i}{A_i + O_i + M_i + I_i} \tag{5}$$

$$D_i = \frac{M_i + O_i}{A_i + O_i + M_i + I_i} \tag{6}$$

S_i: Represents the coefficient of customer satisfaction (i.e., the increasing rate of user’s satisfaction after providing this attribute)

D_i: Represents the coefficient of customer dissatisfaction (i.e. the user’s satisfaction decline if this attribute is not provided)

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A_i, O_i, M_i, I_i represent the percentage of user-selected functions in the operating data, respectively

i=1, ⋯, m, m represents the total number of user requirements

Formula 5 and Formula 6 are used to calculate the customer satisfaction coefficient and customer dissatisfaction coefficient of the same function. The type of functional demand can then be determined by fitting the number into the Si-Di diagram. Among the four demands, the basic needs and the expected needs are the ones that the customer satisfaction will decline linearly without fulfill them. Denote the set of the collection of basic needs and the expected as set B.

(3) Obtain the set of required function modules

The required function module set is constructed based on the mapping of users' functional requirement indicators to product function modules. The realization of a certain functional performance of a product often requires the joint work of multiple functional modules. Corresponding the functional performance index in set B mentioned above with the relevant function modules, the performance-module mapping set can be constructed, and the required function module set will then be obtained, denoted as G, as shown in Fig 2.

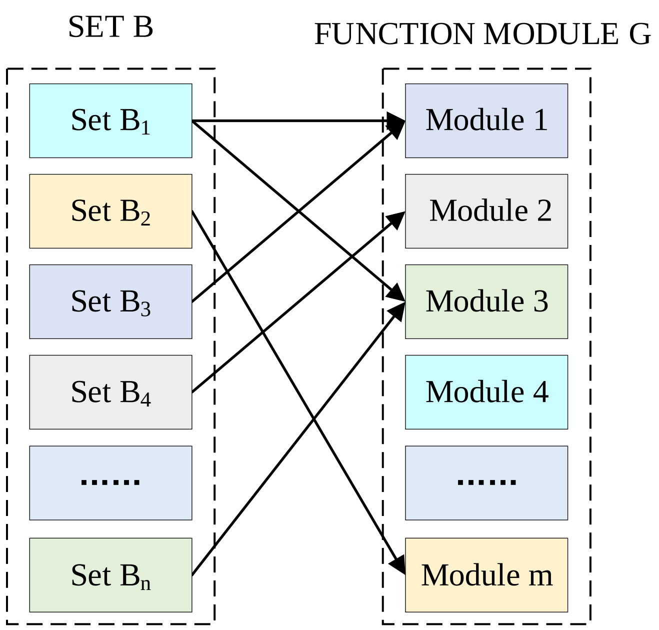

Fig 2: Indicator-module mapping set diagram

3.2 Acquisition of User Segmentation Based on Product Usage Scenarios

A certain product usage scenario is defined as the same usage requirements of a certain product functions. Therefore, by analyzing and clustering the usage information of the product function modules, the product usage scenarios of different user demand levels can be obtained, thereby the user segmentation is realized.

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The usage information of the required function modules is investigated through a questionnaire. Due to the large amount of data and information, it will be difficult to process the data and time consuming. In order to solve this problem, this paper uses R-type clustering to collect each index of the evaluation functions, and then uses Matlab simulation tool to calculate the correlation coefficient between n indexes. The obtained correlation coefficient matrix table is shown in TABLE Ⅲ. By judging the strength of the correlation between two indicators by the correlation coefficient, the simplified indicators are determined. The simplified indicators are used in setting the questions of the survey.

TABLE Ⅲ. Correlation coefficient matrix

	X_1	X_2	X_3	……	X_n
X_1	1				
X_2	a	1			
X_3	b	c	1		
……	d	e	f	……	
X_n	g	h	i	j	1

Note: a, b, c, d, e, f, g, h, i, j denotes the different correlation coefficients respectively.

Based on the data obtained from the questionnaire, module clustering is performed to complete the scene classification. HAC (hierarchical agglomerative clustering, HAC) is mainly divided into agglomeration algorithm and splitting algorithm [12]. In this paper, agglomerative algorithm is selected for cluster analysis, and each user is recorded as a category. Calculating the distance between each two categories, and the two categories that has the shortest distance are merged into one. In this paper, the Euclidean distance is used to calculate the distance and the formula is shown in Equation (7).

$$D = \left[\sum_{k=1}^{p} (x_k - y_k)^2 \right]^{\frac{1}{2}} \tag{7}$$

For each functional module, select an appropriate distance to complete the module segmentation based on usage scenarios, and build a clustering pedigree of users' functional modules based on usage scenarios to achieve user segmentation. That is to say, for a certain user, when a specific functional indicator requirement is obtained, such as a long flight time requirement, the indicator-module mapping set can be used to find the corresponding functional module. And then, based on the user's usage requirement indicator, the usage scenario of the module is located through the module clustering pedigree. Therefore, under the specific usage scenario, the design parameters of the relevant functional modules that can meet the user's satisfaction can then be determined.

Ⅳ. CASE ANALYSIS

In recent years, with the maturity of UAV technology and the reduction of cost, the application of UAV in the civilian industry has become more and more extensive [13-15]. In China, the most agricultural country, agricultural drones can greatly reduce manual labor and realize green unmanned management, which has a broad market space. Agricultural plant protection drones are the most common type of agricultural drones. This article takes DJI T16 plant protection drones as an example for analysis. The

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research team distributed 100 questionnaires to T16 users based on the questionnaires, and recovered 90 valid questionnaires. According to the quality factor table, the corresponding requirement type of the function for a certain customer is obtained, and the customer-function matrix table is obtained by summarizing the requirements of all customers for the function, as shown in TABLE Ⅳ. Then, the attribute type is obtained by calculating the proportion of each attribute dimension.

TABLE Ⅳ. Customer-Function matrix

NEED / USER	NOZZLE NUMBER	BATTERY CAPACITY	REMOTE CONTROL DISTANCE	RADAR IMAGING ALTITUDE	POWER	ALTITUDE	FRAME NOT COLLAPSIBLE	CAMERA PIXEL	HOVER TIME
Ⅰ	A	M	R	I	M	I	A	I	O
Ⅱ	A	I	M	A	A	R	M	O	I
……	……	……	……	……	……	……	……	……	……
XC	A	A	I	R	M	M	I	O	I

According to formulas (1)-(4), the function types to which various functions belong are calculated. The functional properties of Si and Di were calculated as shown in TABLE Ⅴ. Bring it into the quadrant diagram to get the properties of each function, as shown in Fig 3.The functions that belong to the basic needs are included in the set B1. According to the questionnaire data, it can be known that B1={Nozzle number, Battery capacity, Camera pixel, Power }, The functions that belong to the expected requirements are included in the set B2. According to the questionnaire survey data, it can be seen that B2={Nozzles number, Battery capacity }, Combine B1 and B2 into set B to complete the classification of product functions.

TABLE Ⅴ. Summary table of product feature attribute ratios and satisfaction

Features/Services	A	O	M	I	R	Q	Si	Di
Nozzles number	10.0%	30.0%	30.0%	16.0%	8.0%	6.0%	46.5%	-69.8%
Camera pixel	10.0%	24.0%	42.0%	16.0%	0.0%	8.0%	37.0%	-71.7%
Remote control distance	4.0%	26.0%	28.0%	34.0%	2.0%	6.0%	32.6%	-58.7%
Battery capacity	12.0%	28.0%	28.0%	26.0%	0.0%	6.0%	42.6%	-59.6%
power	8.0%	30.0%	36.0%	20.0%	2.0%	4.0%	40.4%	-70.2%
Altitude	12.0%	16.0%	18.0%	46.0%	2.0%	6.0%	30.4%	-37.0%
Frame not collapsible	14.0%	16.0%	26.0%	36.0%	2.0%	6.0%	32.6%	-45.7%
Radar imaging altitude	12.0%	22.0%	28.0%	30.0%	0.0%	8.0%	37.0%	-54.4%
Hover time	14.0%	16.0%	26.0%	32.0%	8.0%	4.0%	34.1%	-47.7%
A:Charm attribute, O:Expected attribute, M:Primary attribute, I:Undifferentiated attribute, R:Reverse attribute, Q:Suspicious attribute								

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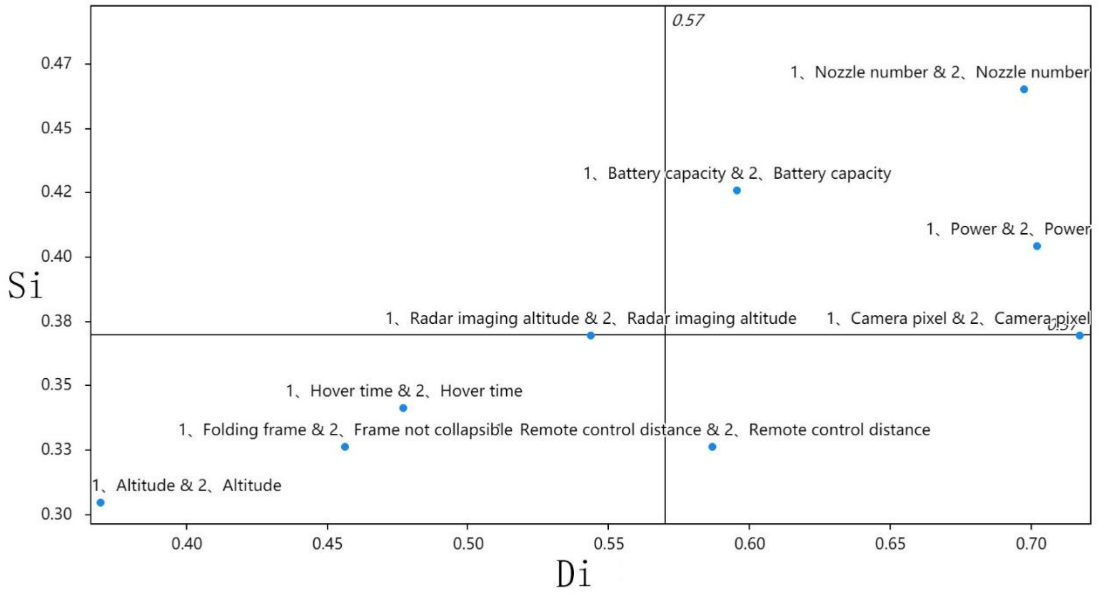

Fig 3: Si-Di four-quadrant chart

The T16 plant protection UAV has the following major functional modules: flight function module, battery function module, rack function module, spraying system function module, radar system function module, remote control system function module, power system function module and Camera function module. The relevant module design parameters can be found on the official website of DJI. The function evaluation index in set B is mapped with the UAV function module, and the index-module mapping diagram is constructed, as shown in Fig 4, and the user demand function module set G is obtained. G={battery function module, camera function module, spraying system function module, power system function module}.

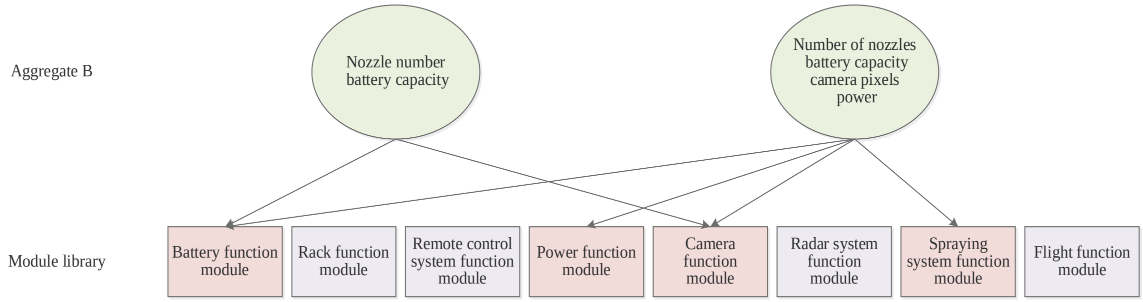

Fig 4: sprinkler system indicator-module mapping set diagram

Since there are too many indicators in different modules, and there is a certain correlation between indicators, the correlation between indicators is calculated and the indicators are simplified. The modules of the spraying system include indicators such as the volume of the operation box X_1, the operation load X_2, the number of nozzles X_3, the maximum system working flow X_4, the spray width X_5, and the atomization particle size X_6 [16]. The indicators are standardized, and Matlab is used to calculate every two The correlation coefficient table between the indicators is shown in TABLE Ⅵ. Clustering the indicators

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according to the degree of correlation obtains the clustering diagram as shown in Fig 5. In Fig 5., the abscissa represents the functional index of the sprinkler system, and the ordinate represents the distance. From the figure, it can be seen from the figure that except for the indicators X_1 and X_2, which are relatively close, the differences between the other indicators are relatively large, so the simplified indicators are jobs. The volume of the box, the number of nozzles, the maximum system working flow, the spray width, and the atomization particle size are five indicators.

TABLE Ⅵ Sprinkler system index correlation coefficient table

	X1	X2	X3	X4	X5	X6
X1	1					
X2	0.999	1				
X3	0.305	0.302	1			
X4	0.176	0.18	-0.198	1		
X5	0.39	0.385	0.081	0.357	1	
X6	0.077	0.073	0.201	-0.274	0.424	1

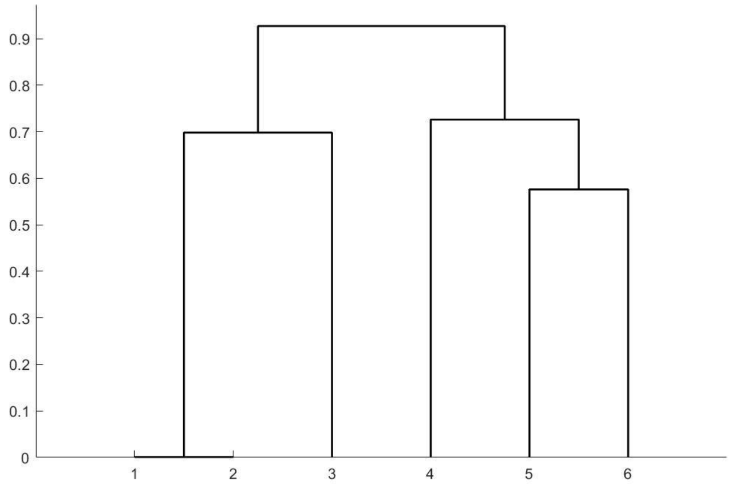

Fig 5: Metric cluster plot

The questionnaire was designed according to the simplified indicators, and the usage data of the corresponding modules were obtained. For example, for the spray system module, investigate the number of times the user has replenished the solvent in a work space of the same size. According to the results of the statistical questionnaire, hierarchical clustering method was used to cluster the usage frequency of the obtained modules, and three types of product usage scenarios were obtained. Customers with capacity needs (the number of times of solvent replenishment is 4-6 times), and customers with large capacity needs (the times of solvent replenishment are 7-8 times). Complete user segmentation. As shown in Fig 6, the abscissa represents 30 users and the ordinate represents distance.

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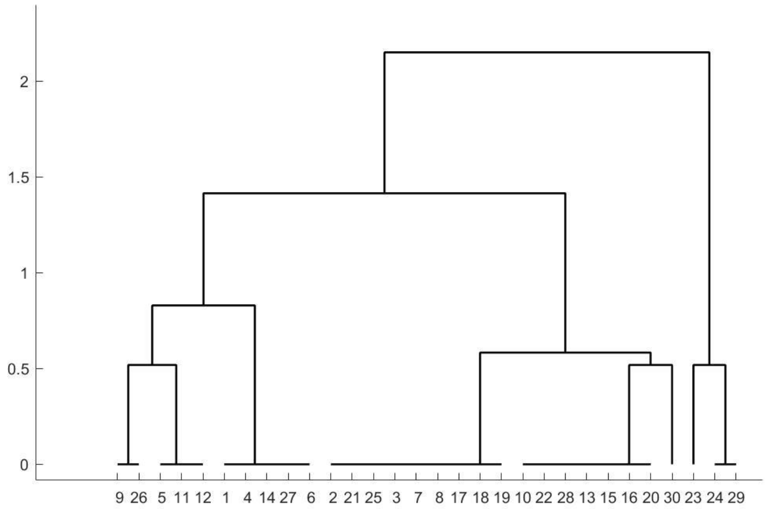

Fig 6: User segmentation chart

V. CONCLUSION

This paper solves the problem that there is no clear correspondence between certain types of users and product functions in user segmentation, and proposes a user segmentation model based on usage scenarios. Using the Kano model, user functional requirements are determined based on uses' functional satisfactions, and a User-FRT matrix is thereby constructed a user requirement functional index set can be obtain. The user requirement functional module set is constructed based on the mapping of user demand function indicators to product function modules. In this paper, the same product functional usage requirements are defines as one product usage scenarios. Therefore, by clustering the usage situation of the function modules, it is possible to obtain product usage scenarios that meet different user demand levels, thereby realizing user classification.

Due to time and resource constraints, this paper uses a questionnaire survey to acquire the relevant data. With the development of the Internet of Things, a large number of smart products are equipped with sensors, and the user's product function usage information can be automatically and accurately obtained through the recorded operation data. The user classification method based on product usage scenarios proposed in this paper can be applied more efficiently.

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