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Interactive Design of Car Steering Wheel Touch Screen Interface Based on KANO Model

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ABSTRACT

With the innovation of automotive hardware and software technology, the application of touch screens and automotive steering wheels has become a new human-computer interaction design trend. The purpose of this research is to improve the driver's experience when using the steering wheel touch screen interface and optimize the steering wheel. The safety, rationality and completeness of the touch screen interaction design. The method of this research is to find the driver's needs when using the steering wheel, filter out various demand research samples, and perform qualitative analysis and quantitative statistics on each demand through the Kano model, thereby constructing the driver's use of the steering wheel. Based on the user satisfaction index coefficient, the demand hierarchy tower when the driver uses the steering wheel is constructed. Through the sensitivity calculation, the importance ranking of each demand is finally obtained, and the design is carried out based on this.

Keywords: Interactive design, Demand analysis, Kano model, Car steering wheel touch screen

INTRODUCTION

Overview of the Steering Wheel

Since its birth, cars have had a vital impact on people's lives. Throughout its more than 100 years of development history, it is not difficult to find that the car is no longer a cold means of transportation, but has gradually become the main body of people's emotional appeal. Excellent human-computer interaction is an important factor to improve the user's driving and riding experience. The steering wheel, as an important contact point for the human-machine interaction in the driver's car, is the place where the interaction occurs most frequently. The experience of using the steering wheel directly affects the quality of the human-vehicle interaction. At the same time, with the development and maturity of assisted driving technology, drivers can focus on more places besides driving, such as entertainment, social interaction, office, etc., which also provides new directions and new ideas for steering wheel interaction design.

Overview of the Research on the Function of the Steering Wheel

In the history of automobile development, the main function of the steering wheel has not changed much, that is, to control the direction of the

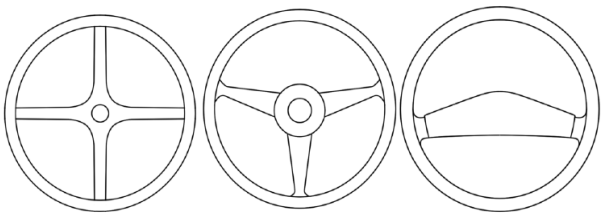


Figure 1: Early steering wheel design.

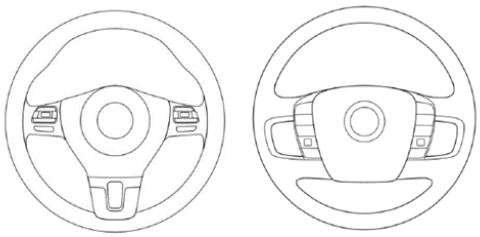


Figure 2: Design of multi-function steering wheel.

car. The early steering wheel design also mainly served the above functions (see Figure 1).

However, with the continuous improvement of functions, the operation has also become complicated and cumbersome. At the same time, people's needs and feelings when driving are constantly changing: they expect to operate various devices in the car more conveniently and safely, which provides designers with more design possibilities. Therefore, placing some function buttons with high operating frequency on the steering wheel is the main design goal of the steering wheel at present (see Figure 2). The current steering wheel mainly adds some multi-function buttons in the modelling area of the ordinary steering wheel to realize remote control of different functions in the car. The control buttons of the steering wheel are generally concentrated in the area on the steering wheel spokes. Through the reasonable arrangement and functional integration of the buttons, the fast and accurate operation of the in-vehicle system can be realized, so as to improve the comfort and convenience of the driver during operation.

With the development of touch screen technology, more and more car companies have begun to use this technology. As we all know, the touch screen interface has more layers than the traditional button interface, which leads to it can provide more functions and services to meet the growing needs of users for in-car interaction. Therefore, applying the touch screen interface to the steering wheel is an important direction of the steering wheel interaction design.

Kano Model and Driver's Needs

The Kano model classifies products or services into five quality types, namely: Must-be Quality (M), One-dimensional Quality (O), Attractive Quality (A), Indifferent Quality (I), Reverse Quality (R). According to the related theory of

the Kano model, a product or service pays more attention to Must-be Quality, One-dimensional Quality, and Attractive Quality. Must-be Quality is usually the basic essential function of a product or service. When Must-be Quality is satisfied, users will pay attention to and care about One-dimensional Quality. One-dimensional Quality is a function expected by users. User satisfaction is proportional to the satisfaction of such requirements. Although users cannot think of Attractive Quality, satisfying Attractive Quality will give Surprise users and greatly improve user satisfaction. The driver's steering wheel usage needs and experience studied in this paper are essentially the research on the intelligent car interaction system and related products of the car controller, and the applicability of the Kano model is high, so this study uses the Kano model to quantitative analysis of class requirements.

RESEARCH PROCESS

The preliminary research method mainly includes the combination of field research method, interview method and observation method to analyze and extract the needs of the driver when using the steering wheel, and then classify, filter and grade the different needs collected, and classify them according to the sorted content. Divided into primary and secondary needs. After that, the questionnaire of the Kano model is designed based on this, the questionnaires are distributed and the results are collected, and the Kano category post-screening index to which each demand item belongs is analyzed, and the user satisfaction index coefficient is introduced to assist in the classification of demand types. Finally, through the user satisfaction and dissatisfaction, the sensitivity of the requirements is calculated, the importance of each requirement is ranked and the priority of the exact requirements is obtained.

RESEARCH ON THE WEIGHT OF STEERING WHEEL FUNCTION REQUIREMENTS

First, the raw data was collected through the literature method, observation method and in-depth interviews with 24 drivers of different representative population types. Then, after keywording the obtained specific demand description, performing word frequency statistics and content classification, a specific initial demand description table (see Table 1). "Secondary requirements" are divided by specific types of functions, and finally "Secondary requirements" related to each other will be formed into "Primary requirements" to obtain a list of drivers steering wheel function requirements (see Table 2).

Determining the Driver Demand Kano Demand Category

(1) Questionnaire design and survey. The questionnaire adopts a standardized form, briefly describes the functions required by the driver in the driving process and sets up two-way questions to obtain user satisfaction evaluation. In this study, drivers of different genders and ages were selected as the survey

Table 1. Survey of steering wheel function requirements.

Description of Requirement		
1 Navigation	9 Steering wheel lock	17 Control dashboard
2 Answer the phone	10 Use bootstrap	18 Meeting
3 Control the direction	11 Reading	19 Control the door lock
4 Play games	12 Cruise control	20 Photograph
5 Voice assistant	13 Vehicle status	21 Singing
6 Watch video	14 Shopping	22 Content recommendation
7 Airbag	15 Control lights	23 Online chatting
8 Control air conditioner	16 Whistle	24 Control the AV system

Table 2. Summary of steering wheel function requirements.

Primary requirement	Secondary requirement	Coding
Manipulate Requirement	Control the direction	MR1
	Control lights	MR2
	Control the door lock	MR3
	Control dashboard	MR4
	Control air conditioner	MR5
	Cruise control	MR6
	Control the AV system	MR7
Entertainment Requirement	Photograph	ER1
	Play games	ER2
	Reading	ER3
	Watch videos	ER4
	Shopping	ER5
	Singing	ER6
Information Requirement	Navigation	IR1
	Voice assistant	IR2
	Content recommendation	IR3
	Vehicle status	IR4
	Use bootstrap	IR5
Safety Requirement	Steering wheel lock	SR1
	Airbag	SR2
	Whistle	SR3
Communicate Requirement	Answer the phone	CR1
	Online chatting	CR2
Office Requirement	Meeting	OR1

objects through a combination of interviews and online surveys. A total of 259 questionnaires were recovered, of which 233 were valid.

(2) Reliability and validity testing. The reliability coefficient value of the results of this questionnaire is 0.822, of which the positive question is 0.924 and the reverse question is 0.908, both of which are greater than 0.8. The reliability of the research data is of high quality. In the validity test, the KMO measure value is 0.873, which is greater than 0.8, which is suitable for factor analysis, and the statistical value of the Bartlett sphere test has a significant probability of 0.000, which is less than 0.01.

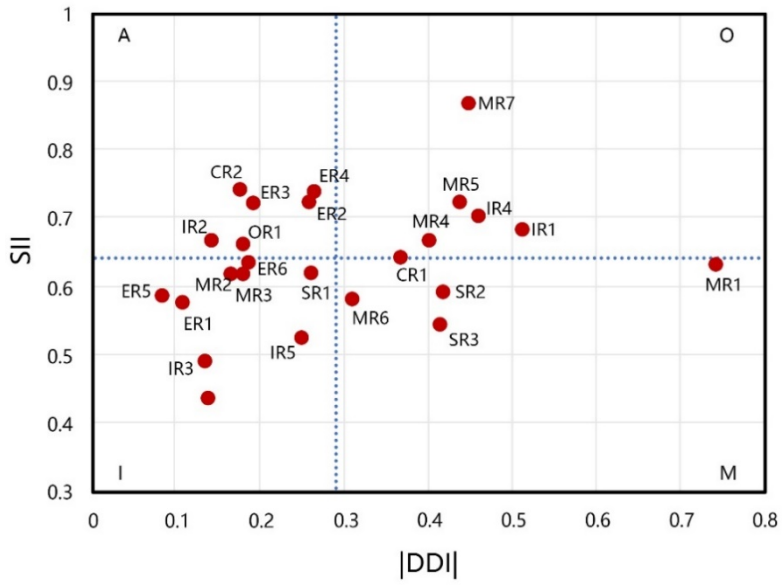


Figure 3: Demand quadrant scatter diagram of Kano model.

(3) Analysis of questionnaire data results and determination of Kano demand category. Compare the Kano model evaluation table, count the Kano category and quantity to which each requirement belongs, and designate A, O, M, I, and R to refer to Attractive Quality, One-dimensional Quality, Must-be Quality, Indifferent Quality, and Reverse Quality respectively. quantity. Since drivers are accustomed to the functions provided by the existing steering wheel, the requirements for new functions of the steering wheel are generally low. According to the classification standard determined by the traditional Kano model with a large proportion of demand categories, most of the obtained Kano demand categories are Attractive Quality, so The user satisfaction index coefficient (CSI) is introduced to assist in the classification of demand types, that is, the closer the absolute value of the user satisfaction increase index (SII) and the user dissatisfaction decrease index (DDI) is to 1, the realization of a certain design attribute will affect users. The larger the satisfaction effect, the smaller the effect is closer to 0. The calculation formulas of SII and DDI are SII =(A+O)/(A+O+M+I) (1) and DDI=(O+M)/(M+O+A+I) (-1).

Determining the Sensitivity and Importance Ranking of Driver Demands

According to the relevant theory of Kano model, Must-be Quality is the basic essential function of products or services. If Must-be Quality cannot be satisfied, user dissatisfaction will increase greatly. One-dimensional Quality is a function expected by users, and users are satisfied the degree of satisfaction is proportional to the degree of satisfaction of this type of demand. Although satisfying Attractive Quality can greatly improve user satisfaction, when it is not satisfied, the impact on user dissatisfaction is not large, so

Table 3. Sample human systems integration test parameters.

Code	A/%	O/%	M/%	I/%	R/%	Q/%	SII/%	|DDI| /%	Category	New category	S	Sensitivity sort	Importance sort
MR1	18.39	43.68	28.74	6.90	0.00	2.30	63.53	74.12	O	M	0.976	2	1
MR2	45.98	14.94	1.15	35.63	1.15	1.15	62.35	16.47	A	I	0.645	20	19
MR3	44.83	16.09	1.15	35.63	1.15	1.15	62.35	17.65	A	I	0.648	19	20
MR4	43.68	21.84	17.24	14.94	0.00	2.30	67.06	40.00	A	O	0.781	7	9
MR5	35.69	34.20	8.55	19.70	0.37	1.49	71.21	43.56	A	O	0.835	5	8
MR6	36.78	19.54	10.34	29.89	1.15	2.30	58.33	30.95	A	M	0.660	18	4
MR7	48.28	36.78	6.90	5.75	0.00	2.30	87.06	44.71	A	O	0.979	1	5
ER1	41.38	9.20	0.00	36.78	9.20	3.45	57.89	10.53	A	I	0.588	22	22
ER2	50.57	20.69	4.60	21.84	0.00	2.30	72.94	25.88	A	A	0.774	8	12
ER3	52.87	17.24	1.15	25.29	0.00	3.45	72.62	19.05	A	A	0.751	10	14
ER4	51.72	19.54	5.75	19.54	1.15	2.30	73.81	26.19	A	A	0.783	6	11
ER5	50.57	6.90	1.15	39.08	1.15	1.15	58.82	8.24	A	I	0.594	21	21
ER6	45.98	17.24	1.15	34.48	0.00	1.15	63.95	18.60	A	I	0.666	17	18
IR1	33.33	34.48	16.09	14.94	0.00	1.15	68.60	51.16	O	O	0.856	3	6
IR2	52.87	12.64	1.15	31.03	0.00	2.30	67.06	14.12	A	A	0.685	15	16
IR3	39.08	8.05	4.60	43.68	2.30	2.30	49.40	13.25	I	I	0.511	24	24
IR4	33.33	35.63	9.20	19.54	0.00	2.30	70.59	45.88	O	O	0.842	4	7
IR5	33.33	18.39	5.75	40.23	0.00	2.30	52.94	24.71	I	I	0.584	23	23
SR1	41.38	19.54	5.75	31.03	0.00	2.30	62.35	25.88	A	I	0.675	16	17
SR2	31.03	26.44	13.79	25.29	1.15	2.30	59.52	41.67	A	M	0.727	12	2
SR3	24.14	28.74	11.49	32.18	1.15	2.30	54.76	41.67	I	M	0.688	14	3
CR1	34.48	26.44	8.05	25.29	4.60	1.15	64.63	36.59	A	O	0.743	11	10
CR2	57.47	16.09	1.15	24.14	0.00	1.15	74.42	17.44	A	A	0.764	9	13
OR1	49.43	14.94	2.30	29.89	1.15	2.30	66.67	17.86	A	A	0.690	13	15

Figure 4: Steering wheel functional requirement hierarchy tower.

the importance of each Kano demand category varies from large the smallest order is Must-be Quality, One-dimensional Quality, Attractive Quality and Indifferent Quality, and based on this, the order of importance of the four gradients is first divided.

The user satisfaction sensitivity is represented by "S", and S is the distance from the point with SII and |DDI| as the coordinate values to the origin. The user satisfaction sensitivity of each function can be visualized in Figure 3. That is to say, according to the characteristics of SII and DDI, the larger the S value, the higher the sensitivity, indicating that whether a certain function is satisfied or not has a greater impact on the user's satisfaction, that is, the higher the importance of the function. Therefore, the importance of the same requirement categories is based on the size of the sensitivity S. That is, the order of importance of each functional requirement can be seen in Table 3.

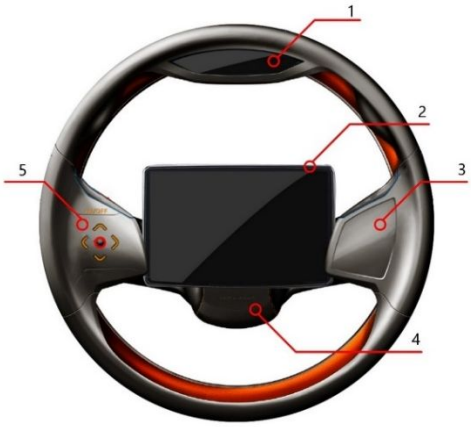
Research Results

According to the results (see Table 2 and Table 3), it can be seen that the Must-be Quality is to control the direction of the vehicle, airbags, whistle, and cruise control. One-dimensional Quality has control of audio and video systems, navigation, vehicle status, control of air conditioning, control of dashboards, and answering calls. Attractive Quality includes watching videos, playing games, chatting online, reading, meeting, and voice assistants. Indifferent Quality has steering wheel lock, singing, light control, door lock control, shopping, photo taking, usage guide, and content recommendation.

Steering Wheel Touch Screen Interaction Design

Design Strategy

The basic strategy for the interactive design of the steering wheel touch screen is as follows: the coverage of Must-be Quality should be guaranteed, and part



1. Vehicle status display screen
2. Steering wheel display screen
3. Trackpad
4. Whistle button
5. Shortcut button

Figure 5: Steering wheel shape design.

Figure 6: High-fidelity prototype of steering wheel touchscreen interface.

of One-dimensional Quality should be properly satisfied, and the driver's Attractive Quality should be further satisfied according to the actual situation, and whether to satisfy part of Indifferent Quality should be selected under certain circumstances.

Design Practice

When designing the interactive design of the steering wheel touch screen, the physical carrier of the touch screen, that is, the shape of the steering wheel, should be fully considered. Consider the human-machine size and interaction area when the user holds the steering wheel, and place the functions with high demand priority in a place that is convenient for the user to operate. Due to the cost of learning, it is not advisable to make too many innovative designs

in terms of shape. Therefore, the shape design results of the steering wheel are shown in the Figure 5.

According to the above design strategy, the interface design of the steering wheel touch screen can be carried out. Since the driver has a ranking of the importance of the functional requirements of the steering wheel, which is reflected in the interface design, the result is that the functions of different importance levels have different areas and entrances, and the interface is carried out according to the design strategy. Design, the design results are shown in Figure 6.

CONCLUSION

Based on the Kano model, this paper aims to meet the driver's steering wheel usage needs through touch screen interaction. This paper takes the driver's steering wheel usage demand as the research object, investigates and classifies it, and maps the driver's demand to the steering wheel function. Through quantitative analysis, the demand category of each function and its importance ranking are obtained, and the touch screen interaction of the steering wheel is proposed. Design strategy, on the basis of this strategy, the preliminary design is carried out, and the design result is obtained. It is hoped that this article will provide a design reference for more diversified human-vehicle interaction methods in the future, and improve the user experience.

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