ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

Research on experience evaluation model of intelligent cockpit based on scenario testing method and computer mathematical statistics

Guo Xin[1,a], Yang Jun[2,b], Zhang Fan[1,c,*]

[1]*China Automotive Information Technology (Tianjin) Co., Ltd., Tianjin, 300000, China*
[2]*Qiyan Automobile Inspection Center (Tianjin) Co., Ltd., Tianjin, 300000, China*
[a]*guoxin@catarc.ac.cn,* [b]*jun.yang@swarc.com.cn,* [c]*m13502037247_3@163.com*
[*]*Corresponding author*

Abstract: *Driven by the iteration of intelligent cockpit technology, the definition mode of automobile intelligence continues to shift to the trend of "hardware defines the depth of automobile and software defines the breadth of automobile". Through the combination of user evaluation and expert evaluation, test cases and traditional quantitative questionnaire, a user experience evaluation method based on scenario test questionnaire is established to establish the research method system of automobile intelligent cockpit user experience.*

Keywords: *Intelligent cockpit, Test cases, Situational questionnaire, User esearch, Software, Hardware*

1. Introduction

The auto industry is undergoing "big changes unseen in a century". From the inside, the consumption of the auto market is becoming more and more mature, and the era of stock competition is coming. The right to speak of the definition of auto products is gradually shifting from the supply side to the consumer side. With the emerging of "Generation Z" The consumer group has gradually grown into the main first-time purchaser, and the form of automobile products is undergoing major changes. Externally, with the rapid development of big data and artificial intelligence, innovation drives change, science and technology empowers innovation, and the Internet "user-centered" experience consumption thinking, cars will become the bridgehead of the fourth industrial revolution. At that time, many technology companies crossed the border to build cars, and some technology companies competed to be tire1 suppliers. At the same time, traditional car manufacturing enterprises and traditional suppliers are equally open to defend the position of the industry. For a time, the battlefield is full of gunsmoke, and the automobile industry has entered the "Warring States era".

The Warring States Period, which is unprecedented in a hundred years, can be summarized as two revolutions, the first energy revolution and the second scientific and technological revolution. Since Karl Ben Ci invented the first car in 1886, the gasoline-fueled internal combustion engine has been used as the main power source for more than a hundred years. However, with the advent of the oil crisis, new energy vehicles driven by electric energy have once again stepped onto the world stage, while pure electric vehicles have achieved explosive growth in the Chinese market. In terms of scientific and technological revolution, new technologies such as 5G communication, artificial intelligence, biotechnology, and new materials have been applied to automobiles. "Whether it is intelligent" has gradually become an important factor for users to choose and judge a car. Voice interaction, touch screen interaction, high-precision Map navigation has gradually become standard, and the rate of equipment such as driver assistance systems, face recognition, HUD, and co-pilot entertainment screens has continued to increase. If Apple has subverted the pattern of the world's mobile terminals, then the emergence of Tesla can be said to have subverted the pattern of the world's auto industry. In the 21st century led by science and technology, the automobile, which has carried more than 100 human beings, has finally ushered in a revolution.

In China, the new forces represented by Weilai, ideal and Xiaopeng are constantly refreshing the three views of traditional automobile enterprises through excellent automobile intelligent cockpit design schemes. More screens, more sensitive voice, more convenient operation experience, faster vehicle speed, the new power of Internet car making, car enterprises have explained what is the car in the new era

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

through innovation. While traditional car companies are still developing for lower fuel consumption, smaller joints, more reliable quality, lower cost and even lower price, Tesla and Weilai Ideal Tucki have begun to look to another track, the intelligent experience of cars.

The intelligentization of automobiles must meet the user experience, what factors do not conform to the user experience of a product in terms of user experience evaluation? We can use the intelligent cockpit user experience design method to carry out[1-3].

2. Intelligent cockpit user experience design

2.1 Smart Cockpit Concept

Compared with the traditional cockpit, the concept of intelligent cockpit will go through five stages, that is, pure mechanical stage-electronic cockpit stage-intelligent assistant stage-man-machine driving stage-the third living space of mankind, as shown in Table 1.

Table 1: Development stage of intelligent cockpit

Stage	Characteristic
0	Purely mechanical
1	Cabin electronization
2	Intelligent assistant
3	Man-machine co-driving
4	Human third living space

The traditional cockpit mainly refers to the coexistence of machinery and cockpit electronization. The smart cockpit is the vehicle's cockpit with more powerful perception-decision-execution capabilities. In terms of internal presentation, it relies more on digital instruments, large screens (including the central control screen, the co-pilot entertainment screen, the function control screen, and the rear row). entertainment screen, etc.), streaming media rearview mirror, head-up display (HUD), smart air conditioner, smart ambient light, voice interaction, gesture interaction and other interactive interfaces and interaction methods, intelligent and networked in-vehicle equipment or services are smart cockpits important features. In terms of vehicle control architecture, the traditional distributed ECU continues to integrate into domain control, and finally will realize the central control integration architecture, and one chip will solve the whole vehicle control. At the same time, as a networked terminal, the vehicle enriches the interaction between "person vehicle road cloud", fully integrates the information of each system, and even realizes the personalized definition of the cab, so that the driver and passengers have a better experience. Finally, with the realization of fully automatic driving, the car will eventually become a third living space that can integrate life, entertainment and office.

2.2 User experience research design

Why pay attention to user experience, no matter the purpose of any product design is to better serve your users, which is why it is user-centric, if the product design is compared to the skeleton, while the experience design is flesh and blood, no matter how perfect the skeleton is, it can only be a dry skeleton. The term "user experience" was put forward by Don Norman in the 1990s, including the process and feeling formed by the interaction between users and products, manufacturers, dealers and after-sales service providers, as shown in Figure 1.

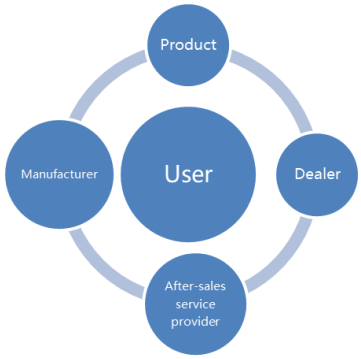

Figure 1: User Experience Relationship

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

The user experience research process consists of 4 steps: first, obtaining user experience stories; second, user experience extraction; third, quantitative data acquisition; fourth, product opportunity point extraction. In user experience refining, we often use user experience journey analysis to describe a user experience through seven elements, as shown in Table 2.

Table 2: User Experience Journey

Experience the journey	Deep experience decomposition
People	Example: Mom and Child
Scenery/environment	Example: kindergarten entrance
Upcoming Tasks	Example: Open the back door and put the children in the back row
Expect	Example: Easy and smooth operation
Function use	Example: unlocking and door opening
Experience accumulation	Example: Vehicles do not provide more humanized functions and are inconvenient.
Recall / summary	Example: Wish the car could be smarter, able to unlock and open the door by itself, embarrassing memories

Another way is the user experience journey map, which focuses more on the process of a user's experience, according to the use process of the car, restore the entire car experience, find the pain points and cool points of users, and carry out innovation and optimization for them, as shown in Figure 2.

Figure 2: Driving experience

3. Evaluation method of intelligent cockpit user experience

Focusing on the user experience evaluation test as the core, according to the user's driving experience process, simulate and restore the real car use scene, and carry out the user experience evaluation test. Taking the user experience evaluation of the products of an independent brand automobile enterprise as an example, we discuss the whole process of user experience research from the aspects of scheme formation, project implementation and research conclusion.

3.1 Test scheme

The core idea of user experience has been introduced in the previous article, which is to divide the scene around the stage of car use， the overall scheme we tested is also evaluated and tested around the specific functions in the vehicle use stage and under the vehicle use stage.

Test scenario: According to the commonly used usage scenarios of users and the feasibility of considering the project execution site and time, the user experience evaluation test is focused on three stages: before driving, during driving, and parking[4-6].

Test function: Accord to that frequency of main functions experience by intelligent cockpit users, test cases can specifically include mobile terminal performance (mobile app), call function, multimedia entertainment, voice interaction, navigation system, LCD instrument interaction, touch screen interaction, driver monitoring, etc.

User experience test tool: Write test cases, and substitute the engineering test cases with more complex use scenarios and tasks into the traditional quantitative test questionnaire, the structure of the questionnaire was revised to form a circular test questionnaire with scene-task-evaluation as the main module.

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

3.2 Test process

Implementation process of intelligent cockpit user experience evaluation: User research (focus) - indicator system construction - user research (use scenarios and pain points) - test case writing - questionnaire writing - user and expert (subject) invitations - venue and vehicle preparation - user testing - data processing - testing Report

In the whole project implementation process, we need to pay attention to the selection conditions of samples. Firstly, two cities need to be selected, one is the user in the main sales area of the product, and the other is the city with high sales of intelligent cockpit benchmark products. Generally, the main sales area of products is the location of the car company headquarters, that is, city A, while the sales areas of smart cockpit benchmark models are Beijing, Shanghai, Guangzhou and Shenzhen, respectively. Users need to fly from the representative city to city A to perform quantitative tests, so try to choose the one that is closer to city A, but due to the epidemic situation, Shenzhen is actually the farthest one, as shown in Table 3.

Table 3: Sample Number and City Selection

Type	Brand	Including vehicle type	Sample size	Shenzhen	City A
This product	Sihao	Sihao QX	17	3	2
Core competitive products	Great Wall	WEY mocha			2
	Auspicious	Xingyue L			2
	BYD	Biadihan			2
	Chang'an	Changan UNI-T			2
	Chery	Tiggo 8 PLUS			2
	Guangzhou Automobile	Aion V			2
Benchmark of new forces	Weilai	NIO EC6	13	2	2
	Ideal	Li ONE		2	2
	Xiaopeng	Xiaopeng P7		3	2
Total			30	10	20

In this aspect, the samples are real user samples and expert samples. Both types of subjects need certain screening conditions to select samples. Considering the allowed period and cost of the project, 30 tested user samples were finally determined. From a statistical point of view, the larger the number of samples, the better. However, too many samples are not recommended for such projects, first, this type of evaluation is not a general product evaluation item. There are not many users with intelligent cockpit use and profound experience. The difficulty of retrieving samples is greater than that of general tests. Second, such test questionnaires require depth due to the addition of test cases. Experience, the test time is longer than the general test, so if there are too many samples, the execution cycle will be too long. In terms of model selection of the tested samples, there are generally two types. As a project test task with the core of mining product use experience, the first test sample needs to include users of benchmark models of intelligent cockpit products, such as Weilai ec6, Xiaopeng P7, ideal one and other model users, as shown in Table 4.

Table 4: user sample boundary conditions

Category	Boundary conditions
City	Shenzhen, city A
Car make and model	See table 3 for details
Pick-up time	3-12 months
Gender	male dominated
Age	Between 20-35 years old
Education	College degree or above, mainly bachelor degree.
Engaged in industry	Mainly engaged in Internet, it, we media, electronics and other emerging industries or independent entrepreneurship
Hobbies and interests	I often have dinner, like to travel, love fashion, especially in go on road trip, and have a strong interest in high-tech products and technologies.
Type of car purchase	It is mainly based on replacement and purchase, and the driving experience should be more than 2 years as far as possible.

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

Kilometers traveled	For more than 3000 kilometers, photos of kilometers shall be provided
Is the main driver?	Yes
Use smart features often	The intelligent functions of the vehicle must be used frequently, such as voice, navigation, face recognition, driving assistance, on-board video, on-board wechat, on-board music, etc
Intelligent use proficiency	Be able to skillfully operate or quickly become familiar with the car system of a vehicle other than your own, which requires the owner to often use the car or be very interested in it.
Intelligent performance of vehicles	The car owner must have a deep understanding of these functions and use them frequently, and be able to recall the usage scenarios of these functions and be able to say what is wrong

As for the samples, it is necessary to invite engineers or professors who specialize in intelligent cockpit evaluation, R&D and research to conduct the evaluation. In this evaluation, the professional engineers engaged in commercial evaluation of our company's test department are invited to participate in the evaluation. The purpose of inviting experts to review is mainly to be able to quickly evaluate on-site and feedback the results of the entrusting party (generally, the user evaluation requires a lot of time due to the large sample size. In fact, in the end user experience report, it is not necessary to over-quote expert evaluation to demonstrate the evaluation. As a result, because it is a user experience evaluation after all, the output of the results still needs to be based on the user results).

3.3 Test case

Traditional test cases are applied to software testing. With the continuous improvement of automobile intelligence level and the trend of software-defined automobile, the software level of interior cockpit is constantly improved. Since traditional quantitative research (such as questionnaire method) can no longer meet the rich functional testing brought about by software definition, a new user experience evaluation test scheme created by combining software test cases and traditional quantitative test scheme is required.

Test case: The English name USE CASE or Test Case refers to the description of a specific software product testing task, demonstrate test plans, methods, techniques and strategies.

Test case dimension: Test cases generally include serial number, test function, detailed function decomposition, test environment, test premise, specific operation steps, expected results, measured results (only for single-sample engineering test), other information remarks, and finally form a document, generally, it can be written in EXCEL form (or use FreeMind, Testlink) , as shown in Table 5.

Table 5: Test case library

Test scope	Test dimension
Mobile terminal	Function, detailed function, test environment, test premise, operation steps, expected result, actual test result, remarks
Call multimedia	
Voice interaction	
Navigation system	
Intelligent driving assistance	

3.4 Test questionnaire

The test questionnaire needs to be prepared in two versions, expert version and user version. Due to the small sample of experts and high self-discipline and freedom, paper questionnaire can be used. The expert version of the questionnaire only needs to specify the evaluation index, without further explanation of the evaluation content or restriction of the test scenario, as shown in Table 6.

Table 6: Examples of Expert Version Test Questionnaire

0 marks	1 marks	2 marks	3 marks	4 marks	5 marks	6 marks	7 marks	8 marks	9 marks	10 marks
No such function	Range	Very poor	Poor	Slightly worse	Slightly inadequate	Just enough	Preferably	Very good	Very nice	Perfect
Scorecard										
P. Please rate the remote vehicle control function of mobile Internet app with 0-10 points. (example)										

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

Index	Expert scoring	Evaluation description
Unlock the vehicle remotely		
Remotely turn on the air conditioner		
Turn on remote seat heating		
Remote on seat ventilation		
Remote lifting window		
Open the remote sunroof		
Send location to car navigation		
Remote start engine		

The user version of the test questionnaire is displayed in the form of a tablet computer, on the one hand, to restrict the respondents from not answering the questions seriously, and on the other hand, to make the later data processing more convenient. In terms of display content, it needs to include the evaluation points of each index. At the same time, the test of intelligent function needs to be substituted into the scene, and the test case is the best way to restore the scene. We call it "Scene" test questionnaire.

It should be noted that the questionnaire should not only contain evaluation indicators, but also include test tasks, that is, users need to complete these established tasks before evaluating indicators, and these tasks also come from the accumulation of previous research, so it is necessary to accumulate specific operations and usage methods in various high-frequency scenarios as test cases and add them to the questionnaire as tasks. On the other hand, it is necessary to mark the main points of the evaluation after the evaluation index, so as to further prompt the user to evaluate the content after the user has completed the predetermined task, thereby reducing the user's unawareness of what evaluation item is being scored risk.

Compared with the traditional questionnaire, the scenario test questionnaire has many advantages and can make up for many shortcomings of the traditional questionnaire. For example, the traditional questionnaire only shows indicators, because the indicators are more from engineering research and development, so the questionnaire writers themselves need to have a high "user language" conversion ability, and need to convert obscure indicators into languages that users can understand, in fact, the authorities are often fans, and it is not easy for the questionnaire writers to do this. They often take it for granted that "the user can't even understand this". Scenario-based test questionnaires can effectively prevent users from randomly answering questions without knowing what they know, as shown in Table 7.

Table 7: Examples of User Version Test Questionnaire

Use Case 1-1:Remote car control Scenario: Imagine today is a sunny day and you are going to drive to work. Please leave the vehicle 5 meters. Assuming that you are in your own home now, you need to set the functions of the vehicle remotely. Task 1: When you see some common functions selected, please operate the remote control of this car according to your usual usage flow and habits. (Note: At this time, the interviewer will hand over the mobile phone that has opened the "XX Passenger Car App" to the respondent.)										
0 marks	1 marks	2 marks	3 marks	4 marks	5 marks	6 marks	7 marks	8 marks	9 marks	10 marks
No such function	Extreme difference	Very poor	Poor	Slightly poor	Slightly insufficient	Just enough	Preferably	Very good	Very nice	Perfect
Comment scoring example notes:										
Xxxxxxx (evaluation index) --- xxxxxxxxxxxxxxxx (evaluation content note of evaluation index)										
P. Please rate the remote car control function of the mobile internet app from 0 to 10.										

Indicator name	Evaluation content	Please rate
Unlock the vehicle remotely	Whether it has the ability to unlock or lock the car remotely with the mobile phone, and whether the operation is convenient	
Remote control air conditioner	Whether it has remote control, such as setting the air conditioner on or the temperature at home, is the operation convenient?	
Remote control seat heating	Is it remote, such as turning on the seat heating at home, and is it convenient to operate?	
Remote control seat ventilation	Whether there is remote ventilation, such as opening the seat ventilation at home, and whether the operation is convenient	
Remote lifting window	Whether it has the ability to lift and lower the windows remotely,	

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

	and is the operation convenient?	
Remote opening sunroof	Can the sunroof be opened remotely (note that the sunroof can be opened), and is it convenient to operate?	
Send location to car navigation	Whether the navigation destination can be sent to the vehicle and set the route in advance, and whether the operation is convenient	
Start the engine remotely	Whether the fuel car can start the engine in advance to warm up the car, and whether the operation is convenient	

3.5 Data processing

In the data processing stage, the scores of indicators at all levels are directly counted through SPSS, and the key point is to determine the weight of indicators, at present, the intelligent cockpit evaluation system includes four modules and three levels. The index scores of the third level are arithmetic mean statistics, and the weights of the second level, first level and modules need to be set to calculate the indexes from the lower level to the upper level, as shown in Figure 3.

① Entropy weight method

step1. Data standardization $Y_j = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}$

Step2. Find the information entropy of each index.

$E_j = -\ln(n)^{-1} \sum_{i=1}^{n} p_{ij} \ln p_{ij} \quad p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} y_{ij}}$

step3. Determine the weight of each indicator

Calculate the weight of each indicator through information entropy: $W_j = \frac{1-E}{\sum_{j=1}^{m}(1-E_j)}$

② Critical model

Step1. Data standardization (same as entropy weight method)

step2. Calculate index variability

step3. Calculation index conflict (correlation coefficient)

Step4. Calculate the amount of information $C_j = S_j^m \sum_{i=1}^{m}(1-r_{i,j}) = S_j^m \times R_j^m$

step4. Calculate the weight $W_j = \frac{C_j}{\sum_{j=1}^{m} C_j}$

③ Comprehensive calculation weight

$w_j = \frac{\alpha_j \beta_j}{\sum_{j=1}^{m} \alpha_j \beta_j} \cdot W = \{w_1, w_2, \ldots, w_j\}$

④ Calculate index score

$X = X \bullet W$

Figure 3: Weight calculation model

With the change of algorithm, EWM (Entropy Weight Method) +CRITIC is used to determine the weight of each index, and the result of data processing is more reasonable after verification, as shown in Table 8.

Table 8: Weights of Smart Cockpit Indicators (Example)

Cockpit module	Weight	First-level indicator	Weight
Cockpit hardware	30%	Cockpit screen	25%
		Atmosphere lamp system	15%
		Sound system	20%
		Intelligent rearview mirror	25%
		Control architecture	15%
Human-computer interaction	40%	Voice interaction	20%
		Touch screen interaction	25%
		Entity key interaction	20%
		Gesture interaction	15%
		Functional interaction	20%
System ecology	30%	Account login and binding	25%
		Software performance	15%
		Mobile terminal performance	35%
		OTA upgrade	25%
Innovative features (plus points)	+5%	Planning class	40%
		Creative class	60%

3.6 Research report

The overall framework of the research report includes project review, product market environment analysis, intelligent cockpit technology comparison and intelligent strategy tracking of competitive enterprises, user characteristics of this product, overall overview of intelligent performance,

ISSN 2706-655X Vol.5, Issue 12: 28-35, DOI: 10.25236/IJFET.2023.051206

interpretation of evaluation results and expert comments on Intelligent cockpit performance. The writing ideas of the research report are arguments, arguments and arguments[7-8]. The whole report focuses on the interpretation of the evaluation results, which accounts for about 85% of the whole report. The contents generally include evaluation results, evaluation analysis and suggestions for innovation and improvement. In terms of analysis and corroboration of evaluation results, quantitative data, VOCs from in-depth user interviews, network big data, on-vehicle follow-up video, network public analysis reports, and basic product parameters are used. (Note: Due to confidentiality reasons, the specific form of the report cannot be displayed)

4. Conclusions

With the increasing popularity of intelligent cockpit at the production end and consumption end, enterprises hope to see the product status of intelligent cockpit of our company's products in the market. Users also hope to purchase vehicles more scientifically by understanding the level of intelligent cockpit of various models. Therefore, the research project of evaluation and testing of intelligent cockpit will be further sought after by institutions, and the current situation and trend are also true. First, all major mainstream automotive vertical media have established their own intelligent cockpit evaluation platforms, followed by non-automotive media, which have begun to establish evaluation institutions. Now gradually, some third-party research institutions have begun to establish their own intelligent cockpit evaluation systems, especially in 2022, the evaluation project of smart cockpit also showed "explosive growth". During this period, we also found that various institutions are also competing for reference. For example, our smart cockpit evaluation system was used for reference by an old portal website. We are also honored and welcome here. After all, our purpose is to conduct a more scientific evaluation of the products on the market. On the one hand, it helps enterprises to bring a sense of real experience based on the user level to provide a basis for product improvement. On the other hand Provide a reference direction for consumers to purchase smart cockpit products.

The reason why the intelligent cockpit has become the hot spot pursued by enterprises at present is that on the one hand, the long-term automatic driving is not easy to realize. On the other hand, as the vehicle body in direct contact with users, the intelligent cockpit is an effective technical path that can improve the user experience through software and hardware iteration. With the continuous evolution of automobile intelligence, "hardware defines automobile depth and software defines automobile breadth" will be the future of intelligent cockpit.

References

[1] Chen Qi. Yan Feng. The "black technology" of automobile intelligent cockpit will be implemented within 5 years [J]. Automobile and Accessories, 2020(13):52-54.
[2] Huang Qiwei, Gao Fengye. Technology is king -- the next decade of China's intelligent networked vehicles [J]. Automobile and accessories, 2020 (16): 30-32
[3] Du Sha, Gao Chi. Dialogue with Wang Jiadong, the head of Faurecia's future cockpit business in China: How can the system supplier carry out the industrialization of "intelligent cockpit" to the end [J]. Automobile and Accessories, 2020(15); 35-37.
[4] Liu Yigang. Research on the trend of intelligent cockpit [J]. Guangdong Chemical Industry. 2019(08)
[5] Riera B., Grislin M., Millot P. Methodology to Evaluate Man-Car Interfaces[J]. IFAC Proceedings Volumes. 1994 (12)
[6] Mao Hongli. The Impact of Language Testing Ontology on English Education in China [J]. Technology and Market. 2009(11)
[7] Cui Weiguo. The next five years of intelligent cockpit [J]. Shanghai Automotive. 2021(02)
[8] Seokhee Na, Sunghyun Lim, Hwa-Soon Choi,Min K. Chung. Evaluation of driver's discomfort and postural change using dynamic body pressure distribution[J]. International Journal of Industrial Ergonomics. 2005 (12)