End User Experience Evaluation of Map Navigation and Location Service

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Abstract. The Map Navigation and Location Service is one of the most popular service types. To analyze the quality of the end-user experience, we identify the key indicators of quality of experience (QoE) for these services, and estimate the weights of these indicators. Based on the SERVPERF model, we collect the feedback data of college students and workers to build an index system of map navigation and location service. Using this index system, we can help users choose high-quality map navigation and location service, and to improve the end user experience for these services.

Keywords: Navigation service · Quality of experience · Location service

1 Introduction

Right now, drivers significantly depend on the online navigation service. Because the urban road conditions are more and more complex, drivers need map navigation service to route [1]. Many navigation service platforms focus on user experience, however, in the current market, we lack unified evaluation of navigation service quality [2–5]. The evaluation index system proposed by our experiment provides methods to evaluate and select high-quality map navigation and location services and provides a reference basis for improving the quality of map navigation and location service. This study also provides an improvement suggestion to current navigation software.

The common methods of user experience evaluation mainly include subjective evaluation methods, behavior data method, interview method, literature method, questionnaire method and physiological methods [6, 7]. By using the above methods, we can understand all the users feel when using the map software. In the process of establishing an index system, it is necessary to design an index system first, and then through rating and analysis by the expert. This study used questionnaire method, literature method, statistical analysis method and AHP hierarchical analysis method, with college students and social people as the sample group [8, 9]. Through literature, interviews, and analysis, 6 primary indicators and 18 secondary-level indicators were finally established to make the index system more objective and reasonable. The reliability analysis makes the

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research results stable and reliable, the effectiveness analysis reflects the effectiveness of the research results, the consistency analysis and the determination of index weight make the results more real and accurate [10–13]. Analytic Hierarchy Process (AHP) provides a powerful tool for the research results [14]. Through the above methods, relatively accurate research results are obtained.

From the results of the survey, college students and social people pay more attention to the security and functionality and empathy of the map services. Map software can improve these three aspects to improve the user service experience and user stickiness [15]. This survey provides a future improvement direction for all map software, provides a reference to promoting the development of map software for multi-level personalized users, and promotes the positive circular development of the software ecosystem.

2 Investigation Method

The evaluation index of map navigation and location service is different from SERVPERF model. According to the particularity of map navigation and location service and user needs, the physical ability of the primary index in the SERVPERF model is removed, and the top-level index such as security and functionality is added. Then the main indicators of more comprehensive addition are obtained through literature and interview methods. Based on the characteristics of the map navigation user group and their requirements, we modify the indicators and questionnaires. For the preliminary construction of map navigation and location service evaluation index platform, design questionnaire, and let users according to their own understanding of the importance of map navigation and positioning service evaluation indicators, rate and evaluation system of relevance to fill out the questionnaire. The smaller the arithmetic mean, the lower the perception to the end users. The indicators with low score of Eq. (1) can be deleted.

$$M_y = \frac{1}{m_y} \sum_{x-1}^{m_x} C_{xy} \tag{1}$$

M_y is the arithmetic average of y index score. m and C_{xy} represent the number of users and the index score respectively. The larger the M_y value, the greater the user thinks that the more important the index is in the evaluation of map navigation and location service. And the smaller the M_y value, the smaller the user thinks the index on the evaluation map navigation and location service.

The degree of coordination is inversely proportional to the coefficient of variation, the greater the coefficient, the greater the user divergence. For the coordination of user opinions V_y, the following calculation methods are adopted in the pre-research:

First, the sample standard deviation for the evaluation results of the y index is calculated, as shown in formula 2:

$$\beta_y = \sqrt{\frac{1}{m_y - 1} \sum_{x-1}^{m_i} \left(C_{xy} - M_y\right)^2} \qquad y = 1, 2, 3 \ldots\ldots, n \tag{2}$$

Then, the coefficient of variation of y index score was calculated, as shown in Formula 3:

$$V_y = \frac{\beta_y}{M_y} \qquad y = 1, 2, 3 \ldots\ldots, n \tag{3}$$

Furthermore, index weighting shows the importance of each index in the whole evaluation system. Reasonable weight distribution can ensure that the evaluation results are more realistic and effective.

First, the judgment matrix of the evaluation index of map navigation and location service is constructed, and the 1–9 scale method is proposed by T.L. Saaty in reference [16].

Factor i versus j comparison of the judgment is a_{ij}, so factor j versus i comparison of the judgment is a_{ji} or $1/a_{ij}$.

The construction matrix is listed below, as shown in Table 1:

Table 1. Scales of judgment matrix 1–9 and their implications

Scale	Meaning
1	Compared with the two indicators, they are equally important
3	Compared with the two indexes, index A is slightly more important than index B
5	Compared with the two indexes, index A is obviously more important than index B
7	Compared with the two indicators, indicator A is more important than indicator B
9	Compared with the two indexes, index A is more important than index B
2, 4, 6, 8	Compared with the two indexes, it is between the two judgment scales
1/3	Compared with the two indexes, index B is slightly more important than index A
1/5	Compared with the two indexes, index B is obviously more important than index A
1/7	Compared with the two indexes, index B is more important than index A
1/9	Compared with the two indexes, index B is more important than index A
1/2, 1/4, 1/6, 1/8	Compared with the two indexes, it is between the two judgment scales

To facilitate the calculation of the weight of map navigation and location service, according to the hierarchical order ranking and the consistency inspection and its consistency inspection, there are the following formulas as follow:

We test *CI* whether A is a consistent matrix, and when $\lambda_{\max}$ larger than n, the more consistent the degree is, so we can test the consistency through this method.

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{4}$$

$\lambda_{\max}$ is the maximum eigenvalue of the matrix A, and the n represents the order of the matrix.

$$CR = \frac{CI}{RI} \tag{5}$$

RI is the average random consistency index, and the value of the *RI* is a set of standard metrics generated by random methods.

$$CR = \frac{\sum_{j=1}^{m} CI(j)a_j}{\sum_{j=1}^{m} CR(j)a_j} \tag{6}$$

Generally, when the consistency ratio $CR < 0.1$, it demonstrates that the inconsistency of A is within the admissible range and can use the normalized eigenvectors as the weight vector, otherwise it needs to be reconstructed into a pair comparison matrix to adjust the A.

Indicator specified processing process is shown in the following Fig. 1:

Step1	Based on the SERVPERF model [17], combined with the particularity of map navigation and location services and user needs, six top-level indicators are selected.
Step2	Several users who have long used map software are selected for interviews to understand their feelings about using map software and discuss the most important performance of map software.
Step3	Summarize the main opinions of the interview, obtain secondary−level indicators.

Fig. 1. Indicators selection flow

Step1	The questionnaire was designed according to Likert scale and the scores were set to 1-5, indicating ' very insignificant, not important, average, important and very important '.
Step2	Several college students who use map navigation and location services are selected to score map software indicators.
Step3	According to the collected scoring data, the formula (1), (2) and (3) is used to calculate the user opinion consistency and user opinion coordination index and compared with the standard value to analyze whether it is reasonable.
Step4	According to the reasonable results, the index system is adjusted. After adjustment, the quality survey is carried out until all indicators are reasonable, and the evaluation index system of map navigation and location service is obtained.
Step5	22 preliminary questionnaires have been released and restored. SPSS22.0 is used to analyze the reliability and effectiveness of the evaluation index system, and to check whether the index system standard.
Step6	The 1-9 scale method proposed by T.L. Saaty was used to compare and analyze various indicators. The questionnaire was designed, and the weight of indicators at all levels was calculated.
Step7	Through (4), (5) and (6) consistency test, check the coordination between the indicators.

Fig. 2. Questionnaire design flow

Table 2. Evaluation indicators of map navigation and location services

Top-level indicators	The secondary-level indicators
Security A	Identity information A1
	Authorized security A2
	Location information security A3
Reliability B	System stability B1
	Navigation accuracy B2
	Sustainability B3
Responsibility C	Route planning delay C1
	Route update delay C2
	Customer service response delay C3
Assurance D	Service quality D1
	Version update D2
	Product brand and strength D3
Functionality E	Search function E1
	Location function E2
	Features E3
Empathy F	Value-added services F1
	Humanized experience F2
	Use costs F3

3 Results Analysis

3.1 Indicator Analysis

The questionnaires created by this experiment will be distributed to full-time students through electronic questionnaires and other ways. This time 22 questionnaires were collected, all valid. The results of the questionnaire were imported into the SPSS22.0 for reliability and effectiveness analysis. Reliability analysis is to calculate the data results obtained and the output data results to determine the stability of the questionnaire. The results of the same survey on the same index reflect the strength of the consistency trend. The safety coefficient of Krenbach α coefficient of level I index is 0.961, reliability coefficient is 0.778, use experience coefficient is 0.858, value-added service coefficient is 0.918, function coefficient is 0.762, and guarantee coefficient is 0.740. The Cronbach's Alpha value of each level index is greater than 0.7, and the overall calculated questionnaire is greater than 0.9, which can verify that the index system is of very high reliability.

Secondly, the evaluation matrix of the evaluation index of the map navigation and positioning system is constructed and the 1–9 scale method proposed by T.L. Saaty is used to compare and obtain the weight: first-level index: safety A, reliability B, use experience C, value-added service D, function E, guarantee F. Secondary-level indicators: identity information A1, authorized security A2, personal security A3. System stability B1, navigation accuracy B2, continuity B3. Route planning delay C1, route update delay C2, problem feedback response delay C3. Quality of Service D1, version update D2,

product brand and strength D3. Search function E1, location E2, feature E9. Personalized service F1, priority customer interest F2, use cost F3. Through the calculation of the research data, the first-level index weight table, the secondary-level indicator weight table and the AHP level analysis results table are obtained. The exact values are shown in the Table 3, 4, 5, 6, 7, 8, 9 and 10 below.

Finally, the weight distribution of the secondary-level indicators in the primary evaluation index and the primary weight in the overall objective evaluation index are the combined weight of the secondary-level evaluation indicators, as shown in Table 11. And we get a Weight graph as the Fig. 3 shown.

Table 3. Questionnaire reliabilities test a value

Dimension	Cronbach a coefficient	N of items
Security	0.961	3
Reliability	0.778	3
Use experience	0.858	3
Value-added services	0.918	3
Functionality	0.762	3
Guarantee	0.740	3
Overall questionnaire	0.960	18

Table 4. A-F weights of grade I indicators

Evaluation index	Security A	Reliability B	Responsiveness C	Guarantee D	Functionality E	Empathy F
Security A	1	3	1	1	3	5
Reliability B	1/3	1	1/3	1/3	1	3
Responsiveness C	1	3	1	1	3	5
Guarantee D	1	3	1	1	3	5
Functionality E	1/3	1	1/3	1/3	1	3
Empathy F	1/5	1/3	1/5	1/5	1/3	1

Table 5. Weights of secondary-level indicators A1–A3

	A1	A2	A3	Wi
A1	1.0	8	8	33.654%
A2	0.8	1.0	9	33.654%
A3	0.8	0.9	1.0	32.692%
Summary of consistency check results				
Maximum characteristic root	CI value	RI value	CR value	Consistency test results
3.000	0.000	0.520	0.000	Pass

Table 6. Weights of secondary-level indicators B1–B3

	B1	B2	B3	Wi
B1	1.0	3	2	31.884%
B2	0.33	1.0	9	33.816%
B3	0.23	0.9	1.0	34.300%
Summary of consistency check results				
Maximum characteristic root	CI value	RI value	CR value	Consistency test results
3.000	0.000	0.520	0.000	Pass

Table 7. Weights of secondary-level indicators C1–C3

	C1	C2	C3	Wi
C1	1.0	5	7	35.577%
C2	0.5	1.0	7	32.692%
C3	0.7	0.7	1.0	31.731%
Summary of consistency check results				
Maximum characteristic root	CI value	RI value	CR value	Consistency test results
3.000	0.000	0.520	0.000	Pass

Table 8. Weights of secondary-level indicators D1–D3

	D1	D2	D3	Wi
D1	1.0	6	7	32.701%
D2	0.6	1.0	9	33.175%
D3	0.7	0.9	1.0	34.123%
Summary of consistency check results				
Maximum characteristic root	CI value	RI value	CR value	Consistency test results
3.000	0.000	0.520	0.000	Pass

Table 9. Weights of secondary-level indicators E1–E3

	E1	E2	E3	Wi
E1	1.0	3	7	34.762%
E2	0.3	1.0	3	33.810%
E3	0.7	0.3	1.0	31.429%

Summary of consistency check results

Maximum characteristic root	CI value	RI value	CR value	Consistency test results
3.000	0.000	0.520	0.000	Pass

Table 10. Weights of secondary-level indicators F1–F3

	F1	F2	F3	Wi
F1	1.0	8	2	32.353%
F2	0.8	1.0	2	31.863%
F3	0.2	0.2	1.0	35.764%

Summary of consistency check results

Maximum characteristic root	CI value	RI value	CR value	Consistency test results
3.000	0.000	0.520	0.000	Pass

3.2 QoE Analysis

In this paper, we adopt several representative AMap, Baidu Maps, Map Bar, Tiger Maps, Search Dog, Navigation Dog Map and so on. This paper analyzes the service platforms of AMap, Tencent Maps, Baidu Maps, and Apple Maps.

In this section, the quality evaluation index system of map navigation and location service is analyzed, and the data collected by the questionnaire survey are used for analysis and calculation to determine samples with judgment scores for each Secondary-level index. The volunteers of this questionnaire are mainly frequent users of map navigation software, almost college students and social people.

In the qualitative index, each Secondary-level index scored in 5 points, indicating very insignificant, not important, average, important and very important, we rank according to our own understanding, according to the importance of the evaluation index and each index, then multiplied by the weight, the overall score, each index is weighted by 10 volunteers, and then multiplied by the weight of the corresponding index for each index. Finally, the comprehensive score is summarized.

In the questionnaire survey, 10 volunteers have both chosen the AMap, and we can find that college students and civil servants are more concerned about C1, E1, F3, that is, Route Planning Delay, Search Feature and Use Cost when using these services. But also, can see that the AMap product service and quality is very good, so we mainly go to the AMap analysis and research.

Table 11. AHP results

Items	Eigenvector	Weight value	Maximum eigenvalue	CI value
A1	1.010	5.609%	18.000	0.000
A2	1.010	5.609%		
A3	0.981	5.449%		
B1	0.952	5.288%		
B2	1.010	5.609%		
B3	1.024	5.689%		
C1	1.067	5.929%		
C2	0.981	5.449%		
C3	0.952	5.288%		
D1	0.995	5.529%		
D2	1.010	5.609%		
D3	1.038	5.769%		
E1	1.053	5.849%		
E2	1.024	5.689%		
E3	0.952	5.288%		
F1	0.952	5.288%		
F2	0.938	5.208%		
F3	1.053	5.849%		

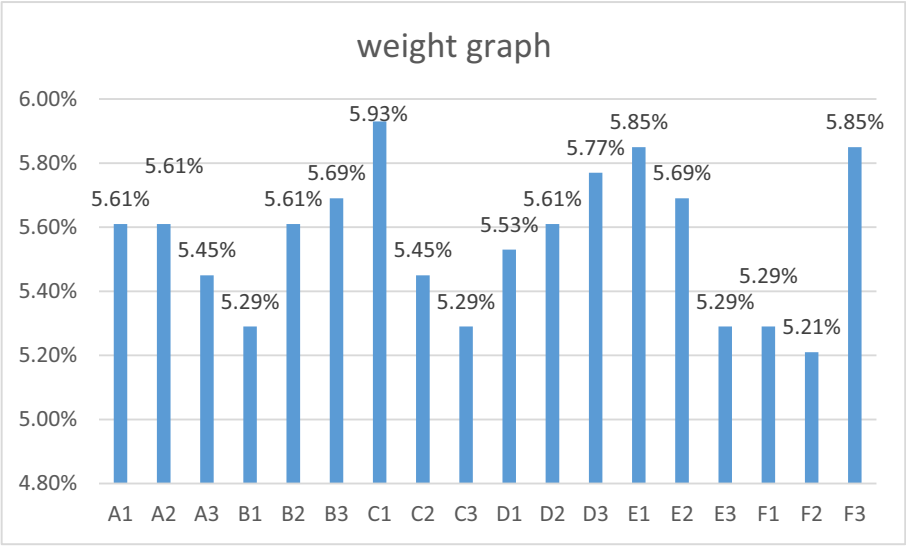

Fig. 3. Weight graph

Table 12. A M_y and V_y analysis was performed for the retrieved questionnaire samples

Selected Map	AMap	AMap	AMap	AMap	AMap	AMap	AMap	AMap	AMap	AMap	M_y	β_y	V_y
A1	4	5	5	5	5	5	4	5	4	5	4.7	0.483	0.103
A2	4	5	5	5	5	5	3	5	4	5	4.6	0.699	0.152
A3	3	5	5	5	5	5	3	5	4	5	4.5	0.699	0.155
B1	3	5	5	4	5	4	3	5	4	5	4.3	0.823	0.191
B2	3	5	5	4	5	5	4	5	4	5	4.5	0.707	0.157
B3	4	5	5	4	5	5	4	5	4	5	4.6	0.516	0.112
C1	5	5	5	4	5	5	5	5	5	5	4.9	0.316	0.065
C2	4	5	5	1	5	5	5	5	5	5	4.5	1.269	0.282
C3	4	5	5	3	5	5	3	5	5	5	4.4	0.843	0.192
D1	4	5	5	5	5	5	4	5	4	4	4.6	0.516	0.112
D2	5	5	5	3	5	5	4	5	5	5	4.6	0.699	0.152
D3	5	5	5	4	5	5	4	5	5	5	4.7	0.483	0.103
E1	5	5	5	3	5	5	4	5	5	5	4.7	0.675	0.144
E2	4	5	5	5	5	4	4	5	5	5	4.7	0.483	0.103
E3	4	5	5	2	5	5	2	5	4	4	4.4	1.197	0.292
F1	4	5	5	3	5	5	4	5	4	4	4.4	0.699	0.159
F2	4	5	5	1	5	5	4	5	4	4	4.2	1.229	0.293
F3	4	5	5	4	5	5	3	5	5	5	4.5	0.707	0.157

From the Table 12, as can be seen, the higher ones are C1, A1, D3, E1, and E2, it also shows the route planning delay, identity information, product brand and strength of AMap, location function in the map products in the forefront. At the same time for other map software can also be used to improve the quality of services. While the lower ones are B1, C3, E3, F1, F2. Customer service response delay, navigation accuracy, features, value-added services, and personalized experience have yet to be improved. For example, AMap is often pointed out that the interface is too large, and so on, so that the user's experience is poor. Despite the high overall rating of the AMap, there are some shortcomings that merit further improvement.

4 Conclusion

At present, there are many map navigation software products in the market, and the quality of each product service is different. We lack a unified evaluation of map quality, software function and performance, and it is difficult for the public to obtain qualified map navigation and location services issued authoritatively. Users will have poor experience when using unqualified map software. The evaluation index system of this experiment provides a tool for users to evaluate and select high quality map navigation and location services and provides a reference for improving the quality of map navigation and location services. Through investigation and analysis, in the primary indicators, people care more about security, functionality and empathy services. Through further analysis, Secondary-level indicators, people pay more attention to the route planning

delay, search feature and use cost. Through the establishment of the index system, some problems existing in the map navigation and location service can be found. In view of these problems, the corresponding improvement suggestions are put forward to improve the service quality of the map navigation and location service products. Therefore, it is expected that the map navigation and location service products can provide better information services and improve the user experience.

According to the results of the user experience survey, customer service response delay, navigation accuracy, features, value-added services, personalized experience has yet to be improved. We can take the following measures to improve the quality of product service. Some professionals can be trained to provide a better service, and some intelligent robot services can be used to improve customer service response delay. When optimizing an upgrade to the software, Map Software Company can add recommended algorithms based on the current location or route duration, and when the current location is identified as Home or Company, the home page will recommend a work route or an off-duty route, prioritizing the recommended time for the user's commute or recording the user's commute time to improve navigation accuracy and experience. For users travelling in different modes of transport, according to the user's history of off-duty navigation time, time-consuming, through the APP push personalized timing to remind users of departure time, push road conditions, etc., to do intelligent commute butler, to solve the problem of users late due to road conditions. At the same time, can cooperate with the audio class APP, the navigation process recommends the audio class content direct entry, for the audio products to draw, meet the user's expectations at the same time to realize the flow of cash. Other map software companies can also adopt the above recommendations to further improve the quality of product service to enhance the user's experience.

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References

1. Liu, M., Zhao, F., Yin, J., Niu, J., Liu, Y.: Reinforcement-tracking: an effective trajectory tracking and navigation method for autonomous urban driving. IEEE Trans. Intell. Transp. Syst. (2021) https://doi.org/10.1109/TITS.2021.3066366
2. Abdelhamid, S., Elsayed, S.A., AbuAli, N., Hassanein, H.S.: Driver-centric route guidance. IEEE Glob. Commun. Conf. (GLOBECOM) **2016**, 1–6 (2016). https://doi.org/10.1109/GLOCOM.2016.7841755
3. Maheshwari, S., Zhang, W., Seskar, I., Zhang, Y., Raychaudhuri, D.: EdgeDrive: supporting advanced driver assistance systems using mobile edge clouds networks. In: IEEE INFOCOM 2019 - IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS), pp. 1–6 (2019). https://doi.org/10.1109/INFCOMW.2019.8845256
4. Ebenezer, R.P., Priya, M.V., Nivetha, B.: GPS navigation with voice assistance and live tracking for visually impaired Travelers. In: 2019 International Conference on Smart Structures and Systems (ICSSS), pp. 1–4 (2019). https://doi.org/10.1109/ICSSS.2019.8882833

5. Klafft, M.: Including weather forecasts in routing decisions of navigation systems for road vehicles: The users' view. In: 2017 36th International Conference of the Chilean Computer Science Society (SCCC), pp. 1–5 (2017). https://doi.org/10.1109/SCCC.2017.8405124
6. Yuling, F., Shengli, D., Lina, Y.: Research on comprehensive evaluation method of user experience in information interaction. J. Inf. Resour. Manage. **1**, 38–43 (2015)
7. Zhang, C.: The Why, What, and How of Immersive Experience, IEEE. Access **8**(1), 90878–90888 (2020)
8. Haiyan, Y.: Research and implementation of evaluation index system optimization. Sci. Technol. Manage. Res. **12**, 128–205 (2009)
9. Tjong, Y., Sugandi, L., Nurshafita, A., Magdalena, Y., Evelyn, C., Yosieto, N.S.: User satisfaction factors on learning management systems usage. Int. Conf. Inf. Manage. Technol. (ICIMTech) **2018**, 11–14 (2018)
10. Wuyi, Z., Bingyi, H.: Analysis of reliability and validity of questionnaire. Stat. Inf. Forum **6**, 11–15 (2005). (In Chinese)
11. Li, Y., Han, Z., He, Q.: Multi-criteria sorting method based on AHP and variable precision rough set. Int. Conf. Mach. Learn. Cybern. **2012**, 261–266 (2012)
12. Boral, S., Chaturvedi, S.K., Howard, I.M., McKee, K., Naikan, V.A.: An integrated approach for fuzzy failure mode and effect analysis using fuzzy AHP and fuzzy MARCOS. In: 2020 IEEE International Conference on Industrial Engineering and Engineering Management, pp. 395–400 (2020)
13. Li, M., Li, Q., Wang, X.: Determination of index weight of minimum price method for technical scoring based on AHP-BP model. In: Conference Proceedings of the 7th International Symposium on Project Management (ISPM2019). Ed. Aussino Academic Publishing House, pp.448–454 (2019)
14. Jinyu, G., Zhongbin, Z., Qingyuan, S.: Research and application of analytic hierarchy process. China Saf. Sci. J. **5**, 148–153 (2008)
15. Wang, Y., Qiu, W.: Optimization of distribution path for community group buying considering customer satisfaction. Tongji University. In: Proceedings of IAECST-International Conference on Traffic and Transportation Engineering and Management. International Conference on Humanities and Social Science Research, Shanghai, China (2019)
16. Saaty, T.L.: Deriving the AHP 1–9 scale from first principles. In: ISAHP 2001 Proceedings (2001)
17. Fragoso, J.T., Espinoza, I.L.: Assessment of banking service quality perception using the SERVPERF model. Contaduría y Administración, 1294–1316 (2017)