Applying AHP Method to Construct App Icon Evaluation Index System

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Abstract. The 21st century is the era of the Internet, and mobile intelligent devices are increasingly becoming an indispensable part of our life, work and entertainment. As an important tool and means of mobile smart devices, APP is becoming more and more abundant in number and variety, and the competition among APP developers is becoming increasingly fierce. The advantages and disadvantages of APP depend on many factors. Based on the visual design of APP icon, this paper summarizes the theoretical overview, design principles and methods, emphatically explores the relevant factors in the design of APP icon, and constructs the evaluation index system of APP icon by using AHP method, and calculates the weight of the relevant factors in APP icon.

1. Relevant Research on APP Icon

1.1. Importance of APP icon
The APP icon is usually the first visual element that users see in the application store when evaluating APP. Bad first impressions can lead to increased sales costs and unnecessary negative reviews, and APP icon will persuade users to get a deeper understanding of the app in a short time.

In the initial positioning and icon design process of APP icon, to ensure that the applications they develop become the best-selling applications in the store, what attractive factors need to be included, are the key factors affecting the excellence of APP icons. Whether the application icon design can be accepted by users, whether it conforms to modern aesthetic trends, and whether it can accurately convey enough information are all factors that should be considered by APP icon designers. These factors should be paid attention to both in the initial design stage and in the updating of APP. If well-developed APP does not have beautiful and attractive icons, it may be buried. Therefore, the design of APP icon is very important for APP.

1.2. Characteristic of icon
Icon design, first of all, requires that it can be quickly identified by users, so as to eliminate or reduce communication barriers between users, in order to shorten the distance between users and them [1]. Compared with text, icon has many advantages, such as easy to recognize, ideographic, efficient and extensive.

(1) Identifiability
The identifiability of an icon is its basic requirement and attribute, and it is also a prerequisite for icon ideographic. Recognition refers to the ability to easily get the information that the icon wants to convey from the icon, and this icon has certain characteristics that are not easily confused with other icons.

(2) Ideography

Ideography is a higher level feature of an object. Icons can express something in a more intuitive and vivid way. Through icons, information such as something, function and so on can be transformed into a simpler symbol to help users understand, recognize and remember in a deeper level. This ideography is also closely related to users' cognitive ability.

(3) Efficiency

The key to using icons is how to convey abundant information to users through the simplest graphics. Icon is a highly generalized expression that abstracts and summarizes some concepts, meanings, functions and things. Although icons are limited in space, they often contain more information and convey more efficiently than languages and words.

(4) Extensiveness

This extensiveness refers to the relative character. In life, when something is not so well expressed directly in words, it is often expressed by drawing simple diagrams; or when there are too many words to describe, language or country or region is not clear, it is also expressed by diagrams. It is precisely because of the universality of such icons that icons can break through the limitations of words and languages and play their role more widely.

2. Relevant Research on AHP Method

2.1. Overview of AHP method

AHP method is called Analytical Hierarchy Process. This is proposed by Thomas L. Saaty. It is mainly used to deal with complex multi-criteria decision-making problems [2]. Through the study, the relative priority of different standard factors is determined to achieve the set goals.

According to the results of American psychologist George Miller's experiment in 1956 [3]. He found that, generally speaking, people can deal with only a certain number of decision-making factors at the same time. When there are fewer decision-making factors to deal with, people's decision-making ability will not be disturbed and become relatively stable and coordinated. When the number of factors involved in decision-making increases, people will also become confused and unable to deal with relevant information better. When dealing with a complex multi-criteria decision-making problem, many criteria make it more difficult to choose. Judgment by relevant industry experts is also vulnerable to too many factors affecting their judgment ability. In this case, how to choose strategies and measures is a complex task.

Usually, the decision-making process involves the selection of alignment criteria and alternatives. However, the importance of each criterion in the scheme is also different. When choosing the scheme, there will be different scheme choices because of different preferences of each person. Therefore, we need a method to measure different schemes and indicators. AHP can decompose a complex multi-criteria decision-making problem into several levels and factors, and then compare these factors in pairs according to the judgment matrix constructed by AHP, so as to establish the weight rating and simplify the complex problem. Therefore, in the face of such problems, the AHP law will be particularly effective. At the same time, when evaluating the priority weight of decision-making factors by AHP method, it can also improve the consistency of objectivity and relative weight, so that decision-makers can take into account all aspects of decision-making objectives more comprehensively.

2.2. Advantages of AHP method

- Reasonable scientificity reduces people's subjective views on some factors.
- Structured system is convenient for decision makers to use and understand
The accuracy of data can reflect the weight values of each factor more accurately. The AHP method is a decision-making tool with reasonable scientificity, systematic structure and accurate data. It is very effective in dealing with multi-criteria decision-making problems.

2.3. The steps of determining weight by AHP method

(1) Establish the structural model of decision-making hierarchy

By decomposing the decision-making problem into the hierarchical structure of several interrelated decision-making elements, the structure of decision-making hierarchy is established. This is an intuitive and most important step in the AHP method. The decision-making problem is first decomposed into three levels: target level, criterion level and index level.

(2) Construct a judgment matrix and compare the decision-making factors in pairs.

The judgment matrix is constructed in the same level, and the decision-making factors are compared in pairs and relevant data are collected.

| Importance scale | Definition of the importance scale |
|------------------|-----------------------------------|
| 1                | Equal importance of \(i\) and \(j\) |
| 3                | Weak importance of \(i\) and \(j\) |
| 5                | Strong importance of \(i\) and \(j\) |
| 7                | Demonstrated importance of \(i\) and \(j\) |
| 9                | Absolute importance of \(i\) and \(j\) |

(3) Calculate the relative weight of each decision-making element in the decision-making hierarchy and test its consistency.

According to the importance value of each element in the decision-making hierarchy and the judgment matrix in the second step, the relative weight of each decision-making element in the hierarchy is calculated, and the consistency of the judgment matrix is checked.

If the importance of each factor in the matrix is recorded as \(W\), then \(w = (w_1, w_2, \ldots, w_n)^T\) is the ranking weight vector of \(n\) hierarchical judgement matrices. In judgment matrix \(A\), the matrix of two-to-two comparisons between elements is as follows:

\[
A = \begin{bmatrix}
  a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\
  a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\
  a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\
  \vdots & \vdots & \vdots & \ddots & \vdots \\
  a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn}
\end{bmatrix}
\]

(1)

The maximum eigenvalues of weight vector and judgment matrix \(A\) are calculated by sum-product method.

a) First, normalize each column element of the judgment matrix:

\[
\bar{W}_{ij} = a_{ij} / \sum_{i=1}^{n} a_{ij}
\]

(2)

b) Calculate the sum of the values of each row of the normalized matrix and get the value of \(\bar{W}_i\):

\[
\bar{W}_i = \sum_{j=1}^{n} \bar{W}_{ij}
\]

(3)
c) Standardize $W_i$ value:

$$W_i = \bar{W}_i / \sum_{i=1}^{n} \bar{W}_i \quad (4)$$

d) The maximum eigenvalue $\lambda_{max}$ of judgment matrix $A$ is calculated:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_{ii}}{nW_i} \quad (5)$$

(4) Compute and sort relative weights and verify them

Judgment matrix is established by analysts based on their personal knowledge and experience. There may be some errors, so consistency testing is needed. Its formula is

$$CR = CI / RI \quad (6)$$

Where

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (7)$$

The RI values are shown in the table below [4]:

| $n$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----|---|---|---|---|---|---|---|---|
| $RI$ | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 |

Therefore, when the consistency ratio $CR < 0.1$, the data of judgment matrix $A$ conform to the consistency standard.

Finally, the relative weights of decision-making factors in each hierarchy are calculated and ranked, and the weight ranking of decision-making factor schemes for target level objectives is obtained.

3. Establishment of App Icon Evaluation Index System

3.1. Analysis of main principles of APP icon design

According to the characteristics and trends of the icon design of APP described in the previous chapter, when we want to analyze the elements of the icon design of APP, the first thing we should consider is the visual elements such as color, shape, layout and so on, which attract the attention of users with icon design elements, and make a comprehensive analysis according to the actual situation. Therefore, this chapter will further study the principles of APP icon design in iOS system from four aspects: the overall picture, layout, graphic elements and color elements.

(1) Overall effect design principles in APP Icon Design

The factors include OVERALL AESTHETIC, STYLE CONSISTENCY, SIMPLICITY and VISUAL APPEAL.

(2) Layout composition design principles in APP Icon Design

The factors included RATIONALITY OF LAYOUT, PROMINENCE OF THEME, APPROPRIATENESS OF PROPORTION and SENSE OF THREE-DIMENSIONAL SPACE.

(3) Design principles of graphic elements in APP icon design

The factors include GRAPHIC IDEOGRAPHY, GRAPHIC RECOGNITION, GRAPHIC CREATIVITY and GRAPHIC EXPRESSIVENESS.

(4) Design principles of color elements in APP icon design
The factors include COLOR SYMBOLISM, COLOR RICHNESS and COLOR UNITY. Based on this, the decision-making hierarchy structure model of APP icon design is established as follows:

![Decision hierarchy model for APP icon design.](image)

### Figure 1. Decision hierarchy model for APP icon design.

#### 3.2. Construction of judgment matrix of relevant indicators and weight calculation

Through expert interview and focus group discussion, five experts in icon design related fields are invited to form focus group. Each expert first records the results of each pair of comparisons independently, and then summarizes all the results of each expert's comparisons. Each expert gives a brief statement of the results of his comparison and gives a brief explanation of the reasons. Finally, experts communicate and discuss, weigh the opinions of other experts and synthesize the results of experimental data. According to the results of the final expert discussion, the data of five judgment matrices, i.e. target level $O$ and decision level $C$, decision level $C_1$ and index level $P$, decision level $C_2$ and index level $P$, decision level $C_3$ and index level $P$, and decision level $C_4$ and index level $P$, are obtained. Specific data are shown in tables 3-7:

#### Table 3. Judgment matrix O-C of target level O and decision Level C.

| $C_1$ | $C_2$ | $C_3$ | $C_4$ | $W$ | Index |
|---|---|---|---|---|---|
| $C_1$ | 1 | 2 | 2 | 4 | 0.4531 |
| $C_2$ | 1/3 | 1 | 1/2 | 2 | 0.1671 |
| $C_3$ | 1/2 | 2 | 1 | 3 | 0.2616 |
| $C_4$ | 1/4 | 1/2 | 1/3 | 1 | 0.1182 |

a. the data conform to the consistency standard

#### Table 4. Judgment matrix C1-P of Decision level C1 and index Level P.

| $P_1$ | $P_2$ | $P_3$ | $P_4$ | $W$ | Index |
|---|---|---|---|---|---|
| $P_1$ | 1 | 3 | 2 | 4 | 0.5011 |
| $P_2$ | 1/3 | 1 | 3 | 1/2 | 0.1721 |
| $P_3$ | 1/4 | 1/3 | 1 | 1/3 | 0.0835 |
| $P_4$ | 1/3 | 2 | 3 | 1 | 0.2433 |

b. the data conform to the consistency standard
Table 5. Judgment matrix C2-P of Decision level C2 and index Level P.

|   | P_5 | P_6 | P_7 | P_8 | W   | Index       |
|---|-----|-----|-----|-----|-----|-------------|
| P_5 | 1   | 2   | 1/2 | 3   | 0.2922 |              |
| P_6 | 1/2 | 1   | 1/2 | 2   | 0.1867 | CR < 0.1    |
| P_7 | 2   | 2   | 1   | 3   | 0.4133 | λ_max=4.0709|
| P_8 | 1/3 | 1/2 | 1/3 | 1   | 0.1078 |              |

c. the data conform to the consistency standar

Table 6. Judgment matrix C3-P of Decision level C3 and index Level P.

|   | P_9 | P_10 | P_11 | P_12 | W   | Index       |
|---|-----|------|------|------|-----|-------------|
| P_9 | 1   | 2    | 3    | 3    | 0.4457 |              |
| P_10 | 1/2 | 1    | 2    | 3    | 0.2848 | CR < 0.1    |
| P_11 | 1/3 | 1/2  | 1    | 2    | 0.1644 | λ_max=4.0709|
| P_12 | 1/3 | 1/3  | 1/2  | 1    | 0.1051 |              |

d. the data conform to the consistency standar

Table 7. Judgment matrix C4-P of Decision level C4 and index Level P.

|   | P_13 | P_14 | P_15 | W   | Index       |
|---|------|------|------|-----|-------------|
| P_13 | 1    | 3    | 2    | 0.5390 |              |
| P_14 | 1/2  | 1    | 2    | 0.1638 |              |
| P_15 | 1/3  | 1/2  | 1    | 0.2972 |              |
e. the data conform to the consistency standar

After calculation, the relative weights of four criterion level factors C_1, C_2, C_3, C_4 and the relative weights of fifteen indices P_2 - P_15 are obtained respectively. We can get the total weight of each index by multiplying the weight of each index with the weight of the criterion level where the index is located. Specific data are shown in Table 8:

Table 8. Number tables of relative weights and total relative weights for criteria level and index level.

| Target level            | Criteria level               | Criteria level weight | Index level       | Index level weight | Total weight |
|-------------------------|------------------------------|-----------------------|-------------------|--------------------|--------------|
| Overall effect design   | principles                  | 0.4531                | overall aesthetic | 0.5011             | 0.2270       |
|                         |                              |                       | style consistency | 0.1721             | 0.0780       |
|                         |                              |                       | simplicity        | 0.0835             | 0.0378       |
|                         |                              |                       | visual appeal     | 0.2433             | 0.1102       |
| Optimum design scheme   | of APP Icon                  | 0.1671                | rationality of layout | 0.2922             | 0.0488       |
|                         |                              |                       | prominence of theme | 0.1867             | 0.0312       |
|                         |                              |                       | appropriateness of proportion | 0.4133             | 0.0691       |
|                         |                              |                       | sense of three- dimensional space | 0.1078             | 0.0180       |
| Design principles of    | graphic ideography          | 0.2616                | graphic ideography | 0.4457             | 0.1166       |
| graphic elements        |                              |                       | graphic recognition | 0.2848             | 0.0745       |
|                         |                              |                       | graphic creativity | 0.1644             | 0.0430       |
|                         |                              |                       | graphic expressiveness | 0.1051             | 0.0275       |
| Design principles of    | color symbolism             | 0.1182                | color symbolism   | 0.5390             | 0.0637       |
| color elements          |                              |                       | color richness    | 0.1638             | 0.0194       |
|                         |                              |                       | color unity       | 0.2972             | 0.0351       |
4. Conclusion

According to the calculation, the total relative weight proportion of the fifteen index levels in the index level can be divided into five categories.

The first category: APP icon design is extremely important indicators, the total relative weight accounted for more than 20%, including indicators: OVERALL AESTHETIC;

The second category: APP icon design very important indicators, the total relative weight of 10% - 15%, including indicators: GRAPHICAL IDEOGRAPHY, VISUAL APPEAL;

The third category: APP icon design more important indicators, the total relative weight accounted for 5% - 10%, including indicators: PICTURE SIMPLICITY, GRAPHIC RECOGNITION, PROPORTIONALITY, COLOR SYMBOLISM;

The fourth category: APP icon design more important indicators, the total relative weight of 3% - 5%, including indicators: LAYOUT RATIONALITY, GRAPHIC CREATIVITY, STYLE CONSISTENCY, TONE UNITY, THEME PROMINENCE;

The fifth category: the general important indicators in the design of APP icons, the total relative weight are less than 3%, including the indicators: GRAPHIC EXPRESSION, COLOR RICHNESS, THREE-DIMENSIONAL SPACE SENSE.

The data and conclusions obtained in this chapter can be used as the basis in the design, research and evaluation of APP icons in the future iOS system, to distinguish the primary and secondary points in the principles of APP icon design, and to design and evaluate the APP icons more pertinently.

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