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**Summary**

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**Key Words:** Grey Relational Analysis, Information Entropy, Analytic Hierarchy Process, KNN algorithm, Principle Component Regression, Bayes Distinction, BP Neural Network Fitting, K-Ford algorithm, BOOST algorithm

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11. **Background**
    1. **Research Background**

With technological advancement and social development, the use of the Internet has gradually become widespread around the world. The Internet now has developed to provide a platform for uses ranging from completing daily demands to conducting research. With respect to completing daily demands, the Internet has provided possibility for online shopping. Given the fact that people nowadays have overwhelmed schedules and heavy workloads due to the fast pace of our society, more and more people prefer to shop online instead of going to department stores and supermarkets in person. However, online shopping possesses deficiencies and inconvenience despite its advantages. Shortcomings like being unable to see the products in person have become the greatest worry among customers as they may risk purchasing low-quality products due to lack of key information presented online. On the other hand, producers also suffer from the worry of selling their products. As a result, determining what characteristics of products are crucial to sales volume is the main challenge for online companies. To solve this problem, we choose a specific kind of product——cellphone——to analyze what kinds of cellphones have the highest sale volume.

* 1. **Current Research Status**

Current Research mainly focuses on several key factors which are considered to influence sales volume. Jie Zhang and Jianan Zhong [Jie Zhang, Jianan Zhong. Research of promotion’s influence to customers’ purchasing behaviors.]conducted research to analyze how sale promotion influences customers’ minds and predict the purchase choices of customers. Gang Du and Zhenyu Huang [Gang Du, Zhenyu Huang. Prediction of customers’ purchasing behaviors in the Big Data environment.] employed the Teradata platform to build decision-making tree model to predict customers’ purchasing behaviors, further improving the efficiency and accuracy of prediction. Zhanbo Zhao, Luping Sun, and Meng Sun [Zhanbo Zhao, Luping Sun, and Meng Sun. Research of comparison between factors in C2C influencing page view and sales volume.] discovered that factors influencing page view and sales volume are substantially different. To be more specific, price, scale, reputation and insurance have significant influence on page view and sales volume. Zhihai Hu, Dandan Zhao and Yi Zhang [Zhihai Hu, Dandan Zhao and Yi Zhang. Empirical research of online comments’ influence on sales volume.] employed sales of skin care products on Taobao as an example to analyze the influence of online comments to sales volume. The aforementioned researches mainly explored certain factors influencing sales volume, but lacked generality. Therefore, online sellers were unable to determine the influential order of all these factors.

With respect to the research methods, current researches mainly employed three methods: Grey Relational Analysis, C2C Model, and BP Neural Network Fitting. As for Grey Relational Analysis, Fatao Wang employed Grey Relational Analysis to determine the main factors for the development of online shopping. Naicong Hou, Xu Zhang, Enjun Zhang [Naicong Hou, Xu Zhang, Enjun Zhang. Grey Relational Analysis of online reputation and sales volume——movie data as an example[J], marketing, 2015(02):28-30] presented reputation as the most influential factor of purchase. Xiao Shi [Xiao Shi. Research of influential factors of online sales based on Grey Relational Analysis.] conducted a quantitive research of the interrelation of sales and price, comment rate, popularity with the utilization of Grey Relational Analysis. As for C2C model, Youzhi Xue and Yongfeng Guo [Youzhi Xue and Yongfeng Guo, Research of the competing strategy of C2C electronic seller: analysis based on Taobao[A], e-commerce, 2012(15),129-140] employed Tobit model to discover that customers valued more on price and delivery fee. Jingsha Fu [Jiangsha Fu. Determining factors of online sales based on C2C.] created a quantify model of influential factors. As for BP Neural Network Fitting, Yanli Ma built an evaluating system including refund rate, descriptions and online comments. All these aforementioned methods are theoretically capable of analyzing the influence of certain factors on sales volume, but are lack of practicality.

In conclusion, current researches have failed to analyze influential factors in a systematic and comprehensive way, and they have failed to reveal specific characteristics that achieve higher sales volume. Therefore, our research results fill in this academic blank by offering a clear view into the characteristics that cellphones with high sales volume have and applying our results to predicting sales volume.

* 1. **Research purpose and significance**

Since online sellers constantly worry about ways to promote sales volume, we conduct research in the hope of offering a practical solution by determining which characteristics contribute to improving sales volume. Our research purposes can be summarized as below:

* To conduct qualitative research to have a general understanding of the characteristics that contribute to high sales volume.
* To conduct quantitative research to rank factors that are considered to have influence on sales volume.
* To determine specific characteristics within each factor that contribute to highest sales volume.
* To predict the sales volume of cellphones with a given characteristic.

Our research results will be of great reference and help to online cellphone sellers by offering clear explanation of what kinds of cellphones have the highest sales volume. Online cellphones sellers can consequently adjust their products according to our research results to achieve higher sales volume.

* 1. **Research method and train of thinking**

Application

BP Neural Network Fitting

Beginning

Data Extraction

Predicting future sales condition

Picking out the needed data

Reducing the number of independent variables

Synthesizing the three methods

BOOST

Sensitivity Analysis

Conclusion

Grey Relational Analysis

Principal Component Analysis

Data Procurement

Entropy of Information

BP Neural Network Fitting

Principal Component Regression

Optimization

Bayes Distinction

Linear Regression

AHP

Basic Statistics

KNN

Modeling

Figure 1: The flow chart of the whole modeling process

After gathering data of information about product selling in AliExpress, we extract useful and relevant data concerning different influential factors for further research. Next, we come to the data procurement to reduce the number of independent factors. In this process, we apply three different method——Grey Relational Analysis, Principal Component Analysis, and Entropy of Information. The Grey Relational Analysis fails to reduce the number of influential factors, while the other two methods effectively complete the goal. Then we apply the results from data procurement for modeling. In the modeling process, we apply results from Principal Component Analysis to Analytic Hierarchy Process, KNN, and Linear Regression. At this point, we have reached the conclusion of the rank of different independent factors. Furthermore, we conduct optimization to each model. We optimize KNN by Bayes Distinction and Linear Regression by Principal Component Regression, while we optimize Entropy of Information to BP Neural Network Fitting. Afterwards, we employ the BOOST algorithm to synthesize the three methods and reach the conclusion that which characteristic contribute to the highest sale volume. Finally, we practice the application of our research results by predicting future sales conditions.

1. **Assumptions**
   1. **Assumptions**

Category Click Rate represents the ratio of the number of people who buy that certain type of cell phone to the number of people who click on the picture online for more detail. Category Convert Rate represents the ratio of the number of people who click on the picture for more detail to the number of people who browse the internet and see the picture of that certain type of cell phone. The advantage of considering these two sets of data as the bases for the information gain is that they not only provide information and reflect the ratio of people who are interested in and actually buy the cell phone, but the data are also in a more consistent and standardized form convenient for the later grouping and processing.

* 1. **Definitions**

Table 1: the definition of notations

|  |  |
| --- | --- |
| Notation | Definition |
|  | The element in Row and Column in matrix |
|  | The independent variables matrix |
|  | Row vector of independent variables |
|  | Row vector of dependent variables |
|  | The algebra average of several data |
|  | Click rate sequence in Grey Relational Analysis or click rate matrix in other parts |
|  | Convert rate sequence in Grey Relational Analysis or convert rate matrix in other parts |
|  | The independent variable sequence in Grey Relational Analysis |
|  | The number in the dependent variable sequence in Grey Relational Analysis |
|  | The number in the independent variable sequence in Grey Relational Analysis |
|  | The difference between each two adjacent terms in independent variable sequences in Grey Relational Analysis |
|  | The difference between each two adjacent terms in dependent variable sequences in Grey Relational Analysis |
|  | Correlation coefficient of dependent variable sequence |
|  | Correlation coefficient between dependent variable sequence and independent variable sequence |
|  | The correlation degree between dependent variable sequence and independent variable sequence |
| Information Entropy |  |
|  | The original variable |
|  | The New variable |
|  | The number of samples |
|  | The number of variables in each samples |
|  | The standardized data at row and column |
|  | The data at row and column before standardization |
|  | The correlation coefficient matrix in principal component analysis |
|  | The characteristic roots or eigenvalues in AHP |
|  | The characteristic vectors |
|  | The th value of the characteristic vectors |
|  | Weight vector in AHP |
|  | The number of choices of target layer in AHP |
|  | The eigenvector in AHP |
|  | Coefficient matrixes of the original data |
|  | Coefficient matrixes of Principal Component Regression |
|  | The probability that satisfies condition |
|  | Reliability in Regression |
|  | Parameters to be estimated of the ensemble in Regression |
|  | The confidence upper limit in Regression |
|  | The confidence lower limit in Regression |
|  | The Mahalanobis distance of the data |
|  | The covariance matrix |
|  | Posteriori probability in Bayes Distinction |
|  | Priori probability in Bayes Distinction |
|  | The frequency at which the sample appears in Bayes Distinction |
|  | The ensemble in Bayes Distinction |
|  | Probability density function of in Bayes Distinction |
|  | The priori probability of In Bayes Distinction |
|  | The number of in Bayes Distinction |
|  | The condition probability of wrongly categorizing the sample of to the ensemble |
|  | The loss caused by the wrong categorization |
|  | A division of a set of distinction samples |
|  | The average wrong distinction loss |

1. **Data Procurement and Process**
   1. **Data extraction**

We obtain a part of the information of the goods having been sold in AliExpress, which is under the control of Alibaba. The original data is in the appendix. With the algorithm and formula given by AliExpress, we convert the original data into the readable and understandable data, which can also be seen in the appendix.

We utilize PYTHON to extract the parameter cells, which contain several standardized description of the phones. With the help of XLRD module and XLWR module, we search for the cells with the assigned field one after another. We divide the searching process into two stages. The first stage is to separate the entire parameters into several fields that contain only one property each; The second stage is to check what each field denotes and use numerical data to characterize the words. For instance, when we search for the battery property, which is either detachable, not detachable, or unknown, we first split the cell by “<br>” which stands for breaks to obtain strings that merely possess one property in lieu of many. Then we use the if function to determine whether the obtained string includes target string, which is “yes” or “no” standing for detachable or not detachable. If it includes the prior one, we define the corresponding value in the new Excel table as 1. If it includes the latter one, we define the corresponding value in the new Excel table as 2. If it includes neither one, we define the corresponding value in the new Excel table as 0, which stands for unknown.

We set Unlock Phones, Google Play, Battery Type, Display Resolution, Operation System, Gravity Response, GPRS, SIM Card Quantity, Size, Battery Capacity, Camera, Recording Definition, Display Size, Brand Name, CPU, Touch Screen Type, RAM, and ROM as the key words for the first stage; we set “yes” and “no” as the key words for the second stage.

In the second stage, there are some special case for us to pay attention to. When we extracting the color parameters, we search the name of the colors individually, for the reason that a page may contain phones with various colors. We use the binary combinations to express the colors of the phones. We set White, Blue, Rose, Gold, Silver, Grey, Pink, Brown, Orange, Yellow, and Red as the detection key words, which allows us to obtain eleven-dimensional binary array to demonstrate the colors. The following figure demonstrates the process.

Parameter: Unlock Phones：Yes <br>Google Play：Yes <br>Battery Type：Not Detachable <br>Display Resolution：1920x1080

……

Camera Type：Front &amp; Back Camera

Camera：12.0MP

Recording Definition：1080P

Display Size：5.5

Front Camera：5MP

Brand Name：xiaomi

Touch Screen Type：Capacitive Screen

ROM：64G

RAM：4G

color：4GB 64GB Black 4GB 64GB Rose Gold 4GB 64GB Gold

Operation System：Android

Google Play：Yes

CPU：Octa Core

Battery Capacity(mAh)：3080mAh /3000 mAh

Unlock Phones：Yes

Display Resolution：1920x1080

Battery Type：Not Detachable

Feature：Gravity Response,GPRS,Touchscreen,Message,Bluetooth,Video Player,HD Video Player,Wi-Fi,Fingerprint Recognition,GPS Navigation,Front Camera,Memory Card Slots,Email

SIM Card Quantity：Dual SIM Cards

Size：154.4x7.3x75.8mm

Highest Camera Resolution：12.0

Recording Definition：1080

Display Size：5.5

ROM：64

Brand Name：1

Touch Screen Type：1

RAM：4

Operation System：1

Battery Capacity：3080

color：0 0 1 1 0 0 0 0 0 0 0

Google Play：1

CPU：1

Unlock Phones：1

Battery Type：2

75.8

Display Resolution：1920

Dual Camera: 1

SIM Card Quantity：2

Feature：1 (Gravity Response)

1080

Size：154.4

7.3

1 (GPRS)

Front Camera: 1

Figure 2: Data Extraction diagram

When we are extracting the highest camera resolution fields, we search all the fields with “camera: ” and comparing the numerical part of all the fields featuring above, retaining the largest one and disposing the rest.

As for extracting the size, we come up with a problem that some of the sizes are expressed in inches, while others are in centimeters or millimeters, which triggers the inconsistency and inconformity of the units. To solve the issue, we first use “x” or “\*” to split the value of three dimensions, before we multiply the 3 parameters, get the volume of the phones, and use a method to determine the critical value that decides the unit of the phones. We select a phone that we regard as normal, calculating the volume among in inches, in millimeters and in centimeters. We then obtain the square roots of the products of the volume in inches and in centimeters, as well as in centimeters and in millimeters, which are regarded as the critical value. We obtain the critical volume value, which are 36.86334 and 4712.451. If the product is less than 36.86334, we regard the unit as inches, then we multiply the length, width and height of the phone with 25.4 to obtain the corresponding value in millimeters. If the product is more than 36.86334 but less than 4712.451, we regard the unit as centimeters, then we multiply the length, width and height of the phone with 10 to obtain the corresponding value in millimeters. If the product is more than 4712.451, we regard the unit as millimeters, then we straight write the length, width and height of the phone into the tables.

Finally we write the value into the Excel table and obtain the data that we use, which can be seen in the appendix.

* 1. **Grey Relational Analysis**

In the real world, it is commonly seen that what influence a system tends to be multi-factors instead of a single counterpart, while the relationship between the factors is complex, which gives rise to the fact that it is easy to cover up its essence with mere regards of its appearance, which makes it difficult to get accurate information and distinguish the primary and secondary factors. The grey system analysis method is essentially an analytic method that replaces discrete data with linked concept.

The grey system theory holds that, although the appearance of the objective system seems to be complicated and the data is irrelevant, it always functions as a whole, which means it is not ramdom but proves to contain some inherent law that can be discovered and explored, and the key is how to choose the proper way to figure out the law of the data and utilize it.

The gray correlation degree is calculated as follows in general: First we standardize the collected evaluation data to ensure that it is treated without dimension; we obtain the sequence of difference and compute the maximum and minimum difference of the sequence of difference; we calculate the correlation coefficient and the calculation correlation degree.

Specifically, we consider the dependent variables, which are click rate and convert rate, as reference sequence. As shown in the appendix, we let the following sequence 1 denotes the click rate sequence

(1)

And we let the following sequence 2 as the convert rate sequence

(2)

We consider the 26 series of independent variables as comparing sequence. As shown in the appendix, we let the following sequence 3 denotes the Google play sequence

(3)

And so on, we let the following sequence 4 as the can-design-product sequence

(4)

Then we standardize the data, making the variance of each sequences change into 1 and the mean into 0. We compute the difference between each two adjacent terms, which can be shown as following formula 5-6:

(6)

(5)

We finally calculate correlation coefficients and the correlation degree, of which the formula is as following formula 7-9.

(9)

(8)

(7)

Table 2: Grey Relational Analysis Result

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Google Play | Battery Type | Battery Capacity(mAh) | Display Resolution | Operation System | SIM Card Quantity |  |
| Click Rate | 0.958033 | 0.958033 | 0.54663 | 0.958033 | 0.958033 | 0.958033 |
| Convert Rate | 0.989033 | 0.989033 | 0.563529 | 0.989033 | 0.989033 | 0.989033 |
|  | Recording Definition (P) | Touch Screen Type | RAM(G) | ROM(G) | CPU | Display Size (inches) | Size |
| Click Rate | 0.958033 | 0.958033 | 0.588991 | 0.337011 | 0.958033 | 0.958033 | 0.771116 |
| Convert Rate | 0.989033 | 0.989033 | 0.570534 | 0.330881 | 0.989033 | 0.989033 | 0.805193 |
|  | Highest camera resolution(MB) | Dual Camera | Front Camera | Brand | Color | Feature | Price |
| Click Rate | 0.771525 | 0.958033 | 0.958033 | 0.958033 | 0.486192 | 0.958033 | 0.555845 |
| Convert Rate | 0.805639 | 0.989033 | 0.989033 | 0.989033 | 0.499513 | 0.989033 | 0.539377 |
|  | SearchCnt | GoodCommentCount | Score | IsGalleryFeatured | IsHighQuality | CanDesignProduct |  |
| Click Rate | 0.752451 | 0.550346 | 0.958033 | 0.958033 | 0.958033 | 0.958033 |
| Convert Rate | 0.722596 | 0.56748 | 0.989033 | 0.989033 | 0.989033 | 0.989033 |

From the obtained correlation degree, we find that the independent variables which have less value in them are apt to have higher correlation values which symbolize that they have a closer connection with the dependent variables. Moreover, the independent variables which have the same number of value possess identical correlation degree, which renders it impossible for us to distinguish how close the connections are between these independent variables and the target dependent variables. We can conclude that the Grey Relational Analysis suits for continuous variables rather than discrete variables, which indicates that it is not an ideal technique for us to determine how tight the relationship is under this situation.

* 1. **Information Entropy**

Information entropy is used to reflect the complexity of the information being processed. Higher information entropy value indicates higher degree of information complexity. Thus, information entropy can be applied to analyze the information in a quantitative way. Information entropy is defined by the formula 10 below:

(10)

where E(X) represents the set of incidents, X, taken into consideration (in the formula above the total number of incidents is n) and represents the possibility that the incident numbered i will happen in the set X. The information entropy is calculated in the form of sum of each individual incident.

However, in determining which factor is more important for us to take into consideration among 26 individual variables related to the cell phone as extracted, what is needed should be the amount of information that can be acquired from analyzing on factor instead of its complexity as reflected by the information entropy. Therefore, we utilize information gain to consider which are the top factors that should be taken into account as the most crucial. In other words, what kinds of factors contribute more or promote the sale of the smart phones in general. The calculation of information gain of each factor involves its information entropy and is a deliberate and complex process. In the next part of this section, we will mainly discuss the data processing related to the information gain.

First, we identify 26 individual variables as the potential contributing or crucial factors for the sale of the phone including Google play, battery type, brand, RAM, ROM, dual camera, front camera, display size, etc. Then, types of data representing the actual sale of cellphones are regarded as the bases for calculating the information gain. Instead of choosing the actual sales volume, we considered the Category Click Rate and Category Convert Rate. Reasons are illustrated in the assumption.

We then divide the Category Click Rate and Category Convert Rate into five groups respectively and reasonably, according to the individual value of the data, from high to low, categorized from 1 to 5. After categorizing the data related to Category Click and Convert Rate, we use the formula above to calculate the global information entropy of those two sets respectively. As applying the formula to the Category Click Rate, E(X) now represents the information entropy of the Category Click Rate, and represents the possibility of category numbered i will happen. Specially, since there are 5 categories, the number n equals to 5. The same can be applied to the Category Convert Rate, and the final results are as following:

Table 3:

|  |  |  |
| --- | --- | --- |
|  | Category Click Rate | Category Convert Rate |
| Global information entropy E(global) | 2.200779 | 2.081891 |

The information we can get from each individual variable is calculated respectively, and the individual variables can be generally classified into two groups: group one with relevant data presenting in inconsistent ways, including factors like Is Gallery Featured and Dual Camera, in which the data only consists of 1, 0, or -1(in other words, the data are expressed in simple forms and can be calculated artificially); group two with relevant data presenting in consistent forms, including factors like Display Size and Display Resolution, in which the data are in various forms and need grouping for further calculation.

As for group one, we take ROM as an example to illustrate how the information entropy is calculated based on the grouping of Category Click Rate. First, we do the grouping and data processing. The data of ROM are presented as discrete variables, including 2, 4, 8, 16, 32, 64, 128, and 256. The grouping of data in ROM should also related to the grouping of Category Click Rate, so accordingly, there are in total 40 groups, which are presented as following:

Table 4:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ROM | Group number in Category Click Rate | 1 | 2 | 3 | 4 | 5 |
|  | 2 | 0 | 3 | 2 | 1 | 0 |
|  | 4 | 5 | 6 | 13 | 7 | 0 |
|  | 8 | 64 | 38 | 63 | 54 | 8 |
|  | 16 | 110 | 89 | 132 | 143 | 36 |
|  | 32 | 64 | 44 | 82 | 63 | 29 |
|  | 64 | 83 | 38 | 62 | 49 | 16 |
|  | 128 | 3 | 4 | 5 | 7 | 0 |
|  | 256 | 0 | 0 | 1 | 0 | 0 |

Let represents the line in the table of the forty groups (as distinguished by double cross lines), represents the column in the table, and represents the number in the unit of the line and column. Thus, in the unit , the number 110 represents there are in total 110 data in ROM that are 16 and also in the group 1 as categorized according to the Category Click Rate. Notice that the sum of all the forty groups should equals to the total number of data(and in our data processing, the total number of data available is 1324).

After the grouping of ROM data related to the Category Click Rate, we further calculate the information entropy of the data in each line, using the formula presented at the beginning of this part. The information entropy of ROM in each line is as the following:

Table 5:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | Information entropy E(ROM i) |
| 0 | 3 | 2 | 1 | 0 | 1.459148 |
| 5 | 6 | 13 | 7 | 0 | 1.89366 |
| 64 | 38 | 63 | 54 | 8 | 2.122787 |
| 110 | 89 | 132 | 143 | 36 | 2.205866 |
| 64 | 44 | 82 | 63 | 29 | 2.242444 |
| 83 | 38 | 62 | 49 | 16 | 2.160525 |
| 3 | 4 | 5 | 7 | 0 | 1.931295 |
| 0 | 0 | 1 | 0 | 0 | 0 |

In order to acquire the total amount of information we can gain from the independent variable ROM, we need to further calculate the possibility that each line will happen. As for the first line A1,j, we calculate the times data 2 appears and then divide the total number of data, 1324. Then, we multiply the possibility to the information entropy of each line, the results are as the following:

Table 6:

|  |  |  |
| --- | --- | --- |
| Information entropy E(i) | Possibility P(i) | Product |
| 1.459148 | 0.004531722 | 0.006612 |
| 1.89366 | 0.023413897 | 0.044338 |
| 2.122787 | 0.171450151 | 0.363952 |
| 2.205866 | 0.385196375 | 0.849692 |
| 2.242444 | 0.212990937 | 0.47762 |
| 2.160525 | 0.187311178 | 0.40469 |
| 1.931295 | 0.014350453 | 0.027715 |
| 0 | 0.000755287 | 0 |

The sum of all the 8 products is the total information entropy we can get from the individual variable ROM. However, for the information gain as related to the Category Click Rate, we need to use the global information entropy of Category Click Rate to subtract the sum of the product above, as the following formula:

IGain(Category Click Rate, ROM) = E(global) -ΣE(i)\*P(i)

where E(global) here represents the global information entropy of the Category Click Rate, since the gain is related to the Category Click Rate. The final gain is as the following:

Table 7:

|  |  |  |
| --- | --- | --- |
|  | Sum of the products | IGain |
| ROM | 2.174619842 | 0.026159369 |

Similarly, the information gain of ROM related to the Category Convert Rate can also be calculated using the method above, and the only difference will be the data in the 40 groups and in the final formula, E(global) should represent the global information entropy of the Category Convert Rate.

As for the group two, we consider the Search Cnt(the number of time that a certain type of phone is exposed to the customer) as related to the Category Click Rate in order to illustrate the difference of data processing from group one. From the data we extracted, it is obvious that the data in Search Cnt are not discrete and the majority of the data of this independent variable are different. However, for the calculation of the information entropy, the number of data in the group should reach a substantial amount, or the final result will be meaningless. Thus we divide the 1324 data in to 5 groups reasonably in order to ensure the number of data in each group for an effective final result.

We divide the data into 5 groups, which are: [0,3000), [3000,30000), [30000,100000), [100000,500000) and [500000, max value). The later data processing part are similar as that for the independent variables in group one. The following table presents the grouping of Search Cnt after the data division.

Table 8:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Search Cnt | Group number in Category Click Rate | 1 | 2 | 3 | 4 | 5 |
|  | [0,3000) | 220 | 2 | 17 | 13 | 2 |
|  | [3000,30000) | 31 | 106 | 107 | 94 | 19 |
|  | [30000,100000) | 34 | 43 | 77 | 66 | 8 |
|  | [100000,500000) | 29 | 61 | 96 | 81 | 8 |
|  | [500000, max value) | 15 | 10 | 63 | 70 | 52 |

The data can later be processed as the same way above, and the final information gain of the Search Cnt related to the Category Click Rate is as the following:

Table 9:

|  |  |  |
| --- | --- | --- |
|  | Sum of the products | IGain |
| Search Cnt | 1.808392333 | 0.392386753 |

As for other individual variables whose data are not discrete numbers, the same data processing method can be applied. Thus, the information gain of each 26 individual variables as related to the Category Click Rate and Category Covert Rate can thus be calculated. The final information gain is presented in the two tables following:

Table 10 : Information gain of each individual variables related to the Category Click Rate

|  |  |
| --- | --- |
| Comment Count | 0.732792417 |
| Good Comment Count | 0.680453664 |
| Search Cnt | 0.392386753 |
| Score | 0.173242295 |
| Brand | 0.124112475 |
| is gallery featured | 0.060358001 |
| Battery Capacity(mAh) | 0.050232189 |
| RAM(G) | 0.031072544 |
| Size | 0.028079662 |
| Highest camera resolution | 0.026589357 |
| ROM(G) | 0.026159369 |
| Price | 0.02284587 |
| color | 0.021268354 |
| Display Resolution | 0.019607145 |
| feature(gravity and GPRS) | 0.016959237 |
| is high quality | 0.016942427 |
| CPU | 0.016022113 |
| Recording Definition (P) | 0.012770426 |
| Display Size | 0.011465334 |
| Battery Type | 0.010742922 |
| Touch Screen Type | 0.008087216 |
| Operation System | 0.006372009 |
| SIM Card Quantity | 0.006106585 |
| Front Camera | 0.001569914 |
| Dual Camera | 0.00153786 |
| Google Play | 0.000108253 |

Table 11: information gain of each individual variables related to the Category Convert Rate

|  |  |
| --- | --- |
| Comment Count | 0.950131659 |
| Good Comment Count | 0.910616696 |
| Search Cnt | 0.631528548 |
| Score | 0.288394004 |
| brand | 0.261397755 |
| Is Gallery Featured | 0.220147548 |
| Battery Capacity(mAh) | 0.102065066 |
| Highest camera resolution | 0.067310002 |
| Color | 0.052728838 |
| Size | 0.052070786 |
| Price | 0.040606491 |
| RAM(G) | 0.040286271 |
| ROM(G) | 0.039561052 |
| Recording Definition (P) | 0.038203566 |
| CPU | 0.037314954 |
| Display Resolution | 0.032897632 |
| Battery Type | 0.0300117 |
| feature(gravity and GPRS) | 0.024420792 |
| Display Size | 0.020633742 |
| Is High Quality | 0.014778733 |
| SIM Card Quantity | 0.010565193 |
| Operation System | 0.008369328 |
| Front Camera | 0.006603513 |
| Touch Screen Type | 0.005934561 |
| Google Play | 0.005319893 |
| Dual Camera | 0.002904891 |

The higher the information gain of the individual variable indicates the higher the importance of that factor contributing to the sale of the product. Thus, when deciding which variables are more crucial and can be taken into account for the modeling further, the method of information entropy is a relatively clear and reliable way.

* 1. **Principal Component Analysis**

We can still do as part 4.3, regarding the sales condition as dependent variables and the properties of phones as independent variables. We try to reduce the dimensionality, diminishing the vast amount of the original data and variables into less data and variables, while the new variables can retain the information in the original data by and large.

We utilizes the 26 original variables mentioned in 3.4 as the original data. We still use to denote independent variables matrixes, . The original variables are ; the new variables are . We use to denote the number of samples; we use to denote the number of variables in each samples. Thus the data matrix is as matrix 11

(11)

Since the data varies in dimensions and ranges, we need to standardize the data. We adopt variance standardization technique to operate the data so that the variance of the standardized data is 1, while we conduct the central translation so that the mean of the data is 0. The formula is as formula 12-14

(12-14)

denotes the standardized data at row and column ; denotes the data at row and column before standardization. denotes total column number and denotes total row number.

Then we establish the correlation coefficient matrix , of which the formula are as the following formula 15-16.



(15)

(16)

Then we obtain the characteristic roots which satisfy for and characteristic vectors to determine the load on each new principal component variables of the original variables , which are equal to the larger characteristic values of the correlation matrix corresponding to the characteristic vectors. is the value of the characteristic vectors. The formula is as formula 17

(17)

In the formula, denotes each characteristic vectors, denotes each characteristic value. The characteristic roots are in the following table 25. Characteristic vector matrix is in the appendix.

Table 12: Principal Component Regression Characteristic Value

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 5.830569 | 2.108099 | 2.023791 | 1.548141 | 1.270862 | 1.142889 | 1.079039 |
| 0.984911 | 0.973456 | 0.896728 | 0.878234 | 0.848337 | 0.823186 |  |
| 0.770015 | 0.68834 | 0.646611 | 0.571062 | 0.49684 | 0.465049 | 0.413485 |
| 0.364857 | 0.324523 | 0.276729 | 0.245753 | 0.200672 | 0.127823 |  |

Since the data is standardized before the analysis, each coefficients are equally likely. We can use the independent variables of which the principal component coefficients are relatively larger in the first several principal components. Thus we obtain 6 properties of the phones for further analysis, which are Display Resolution, Recording Definition, RAM, ROM, CPU, Highest camera resolution, and Price.

1. **Modeling**
   1. **Basic Statistics**

After obtaining the original data, we do the basic statistics process. We set the click rate and the convert rate as the dependent variables, while other variables as independent variables. On the one hand, we make pie charts as well as line charts to reveal the proportions of the phones with each characteristics over the ensemble, as shown in figure 5-6. On the other hand, to show the cross relationship between the independent variables and dependent variables, we draw the bivariate tables to reveal the proportions of the phones with each characteristics over a certain type of phones. We first categorize the continuous variables into several ranges, in order to discretize the variables. Table 20 is the statistic table of Battery Capacity. We divide the click rate into 5 categories, which are 0-0.1, 0.1-0.2, 0.2-0.225, 0.225-0.3, 0.3-0.464. We divide the convert rate into 5 categories, which are 0-0.1, 0.1-0.2, 0.20-0.22, 0.22-0.23, 0.23-0.468.

Figure 3: Line Chart of Battery Capacity

Figure 3: pie Chart of System

Table 13: Statistics from Battery Capacity to Click Rate Category

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Clickrate Catagory  mAh | 1 | 2 | 3 | 4 | 5 |
| Lower than 3000 | 93 | 67 | 92 | 88 | 14 |
| 3000 | 59 | 40 | 66 | 60 | 8 |
| More than 3000 but less than 4000 | 80 | 57 | 85 | 79 | 16 |
| 4000mAh to 4100 | 24 | 19 | 53 | 60 | 42 |
| More than 4100 | 73 | 39 | 64 | 37 | 9 |

* 1. **Analytic Hierarchy Process**

In order to choose in diverse factors and judge the sales of certain types of phones, we utilizes Analytic Hierarchy Process(AHP) to achieve the goal which is to determine the weight of each options in complicated and uncertain problems. We define the properties of the phones, which are display resolution, recording definition, RAM, ROM, CPU core, highest camera resolution, and price, obtained from the Principal Component Analysis, as the scheme layer, while defining the click rate and the convert rate as the target layer, to build up the AHP model with one mere layer but several groups. We divide RAM in to 3 groups, less than 1 GB, no less than 1 GB but less than 4 GB, and more than 4 GB, of which are groups 1, 2, and 3 respectively. We divide ROM in to 3 groups, less than 8 GB, no less than 8 GB but less than 64 GB, and more than 64 GB, of which are groups 1, 2, and 3 respectively. We also divide display resolution, recording definition, highest camera resolution, and price into several categories, of which the standard is the same as what we do in the Information Entropy part. Figure 7 shows the diagram from RAM to click rate.

 Figure 4: AHP structure diagram

First, we define the amount of phones that possess certain properties under a certain type of sales conditions, which refers to the amount of a certain target choice under a certain scheme layer condition, as . In accordance with the target choice, we obtain a weight vector ( stands for the number of choices of target layer). We compute the ratio between the number, , of each scheme layer choices under a common target layer choice and regard them as the weight of paired comparison matrix. As they are consistent matrixes, we do not need to apply consistency tests to the matrixes, for they are automatically consistent, which means the eigenvalues are all identical. With the help of the formula of the eigenvalue and eigenvectors shown as following formula 18,

(18)

we can obtain the eigenvectors, . Composing the eigenvalues of each scheme layer, we obtain the eigenvector matrixes as well as weight vector matrixes from target layer to scheme layer.

Then we repeat the process from each scheme layer, which is the sales condition, to each target layer, which is the properties of the phones, to achieve the goal that for each schemes the sum of the weight vector is 1 to transversely compare which option is more welcomed under the same sales condition. Comparing the weight of each schemes to one single target vertically, we obtain which kinds of phones are more welcomed under the same standard.

Finally, we draw the statistical chart with each weight vector, such as stacked column charts, to clearly express the interference of the properties of the phones to the result. The charts are shown in the appendix, one of which is shown as figure 8.

Figure 5: AHP result analysis

From the figure in the appendix, we can clearly see that phones with middle display resolution tend to attract more customer to click in and purchase. Phones with lower and higher recording definition are more welcomed, while phones with medium counterpart are less intriguing. Phones with lower RAM, ROM, and CPU involve in more click rate, whereas phones with higher equivalents involve in more convert rate.

For both highest camera resolution and price, the medium ones are both attractive.

* 1. **Linear Regression**

The third method we use is linear regression. We can regard the properties of phones as independent variables, and the sales as dependent variables. Based on the samples, each data can be viewed as a mapping from the independent variables, which are the properties, to the dependent variables, which are sales. As each data is expressed numerical, we can from the given data to find the function from the independent variables to the dependent variables through linear regression.

Let to respectively denote display resolution, recording definition, RAM, ROM, CPU core, highest camera resolution, and price. Let denotes click rate and denote convert rate. The value of the independent variables and dependent variables are the numbers of each options.

We utilizes regression formula 19,

(19)

Let denotes the independent variables matrix, denote dependent variables matrixes, denotes coefficient matrixes. We apply Least Square Regression Method to the issue, of which the formula is shown as the following formula 20

(20)

The formula is set to solve out the value of the coefficient matrixes of point estimation. With MATLAB giving solution, we obtain the coefficient matrixes which are as following table 14.

Table 14: Linear Regression Coefficient

|  |  |  |
| --- | --- | --- |
|  | Click Rate | Convert Rate |
|  | 0.017671 | 0.018321 |
|  | 7.71E-10 | 6.24E-10 |
|  | 1.83E-06 | 1.68E-06 |
|  | -0.00055 | -0.00053 |
|  | 8.85E-06 | 8.64E-06 |
|  | -0.00062 | -0.00081 |
|  | 2.61E-06 | -9.50E-06 |

Point estimation possesses a drawback that it cannot express the accuracy of the data obtained, thus we utilizes interval estimation to reuse the Least Square Regression Method, the formula as following formula 21.

(21)

denotes the parameters to be estimated of the ensemble; denotes probability; denotes Confidence upper limit; denotes Confidence lower limit; denotes reliability which satisfies . In this way, we obtained formula 22

(22)

With MATLAB program, we set as 0.95, under which the regression coefficient bound is as following table 15

Table 15: Linear Regression Coefficient Bound

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Click Rate Lower Bound | Convert Rate Lower Bound | Click Rate Upper Bound | Convert Rate Upper Bound |
|  | 0.013262 | 0.013966 | 0.02208 | 0.022677 |
|  | -5.27E-10 | -6.58E-10 | 2.07E-09 | 1.91E-09 |
|  | -2.08E-06 | -2.20E-06 | 5.75E-06 | 5.55E-06 |
|  | -0.0014 | -0.00136 | 0.0003 | 0.000311 |
|  | -3.08E-05 | -3.06E-05 | 4.85E-05 | 4.78E-05 |
|  | -0.00195 | -0.00212 | 0.000702 | 0.000499 |
|  | -0.00019 | -0.00019 | 0.00019 | 0.000185 |

Residual graphs are in the appendix, one of which shown as following figure 6. When examining correlation coefficients, we find the correlation coefficients are as the following table 16.



Figure 6: Residual Case Order Plot of Linear Regressionn

Table 16: Linear Regression Correlation Coefficient

|  |  |
| --- | --- |
| Click Rate | Convert Rate |
| 0.011722 | 0.011268 |

* 1. **KNN Algorithm**

In accordance with the given data, we try to randomly sample two-thirds of the data as learning samples and one-third of the data as the test data to highly merge the vast amount of the data and find the shared features and characteristics of each samples to obtain the common properties of the phones under similar sales condition to determine the relationship.

We utilizes Mahalanobis distance distinction to operate these data, which is processed after principal component analysis and features eradicating the dimension of each independent variables. The formula is as the following formula 23.



(23)

Among the formula, and denote two row vectors; denotes the covariance matrix; denotes the obtained Mahalanobis distance of the data.

The comparison between the distinction result and the real result is shown in table 17, which shows the accuracy of the distinction. In light of the fact that the accuracy is relative low, which is insufficient to reveal the features of each variables precisely, we consider to take the advantage of other methods.

Table 17: Linear Regression Correlation Coefficient

|  |  |
| --- | --- |
| Click Rate | Convert Rate |
| 0.115124 | 0.162528 |

1. **Optimization**
   1. **Principal Component Regression**

We can still do as part 4.3, regarding the sales condition as dependent variables and the properties of phones as independent variables. We try to reduce the dimensionality, diminishing the vast amount of the original data and variables into less data and variables, while the new variables can retain the information in the original data by and large.

We utilizes the 26 original variables mentioned in 3.4 as the original data. We still use to denote independent variables matrixes, . The original variables are ; the new variables are . We use to denote the number of samples; we use to denote the number of variables in each samples.

After the work in part 3.4, we apply the contribution rate formula and the total contribution rate formula 24-25.

and 

(24-25)

We obtain the total contribution rate until the fourteenth principal component is 81.45%, which is larger than 80%. Therefore, we take the first fourteenth eigenvalue as the principal component. Suppose the principal component is formula set 26

(26)

Applying Least squares regression, point estimation and interval estimation method which has previously been mentioned, we obtain the principal coefficient matrix as shown in table 18 with formula 27.

(27)

Table 18: Final Coefficient Matrix

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Click rate | Convert rate | Click rate bond | | Convert rate bond | |
| 0.006462 | 0.0062 | 0.004059 | 0.008866 | 0.003961 | 0.008439 |
| -0.00041 | -0.00037 | -0.00051 | -0.00032 | -0.00046 | -0.00028 |
| 0.0002 | 2.03E-05 | -0.00024 | 0.000636 | -0.00039 | 0.000427 |
| 0.002007 | 0.001957 | 0.001797 | 0.002217 | 0.001762 | 0.002153 |
| 0.000336 | 0.000307 | 0.000162 | 0.00051 | 0.000145 | 0.000468 |
| 0.000999 | 0.0011 | 0.000672 | 0.001325 | 0.000796 | 0.001405 |
| -0.00419 | -0.00407 | -0.00458 | -0.00379 | -0.00444 | -0.0037 |
| 0.001884 | 0.001854 | 0.001271 | 0.002498 | 0.001283 | 0.002426 |
| -0.00422 | -0.0042 | -0.00502 | -0.00343 | -0.00494 | -0.00347 |
| -0.0012 | -0.00111 | -0.00209 | -0.00031 | -0.00194 | -0.00029 |
| 0.000897 | 0.000965 | 0.000346 | 0.001447 | 0.000452 | 0.001478 |
| -0.00077 | -0.00071 | -0.00107 | -0.00047 | -0.00099 | -0.00043 |
| -0.00069 | -0.00067 | -0.00091 | -0.00048 | -0.00087 | -0.00047 |
| -0.00056 | -0.00059 | -0.00098 | -0.00014 | -0.00098 | -0.0002 |
| -0.00091 | -0.0009 | -0.00106 | -0.00076 | -0.00104 | -0.00076 |

The correlation coefficients of this method are 0.805032 and 0.826614, which are satisfactory for further calculation. Ultimately, we conduct the inverse standardization process and obtain the equation interpreted in the original data, which is formula 28, and the final coefficient matrix, as shown in table 19.

(28)

Table 19: Final Coefficient Matrix

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Click rate | Convert rate | Click rate bond | | Convert rate bond | |
| 0.0064624 | 0.00620011 | 0.00405878 | 0.00886602 | 0.00396136 | 0.00843887 |
| -0.0007861 | -0.0008376 | -0.001242 | -0.0003302 | -0.0012622 | -0.0004129 |
| -0.0002066 | -2.14E-04 | -0.0004761 | 6.30E-05 | -0.0004647 | 3.74E-05 |
| 1.42E-08 | 4.98E-08 | -0.0004646 | 0.00046463 | -0.0004327 | 0.0004328 |
| 4.31E-10 | -3.61E-09 | -0.0001314 | 0.00013144 | -0.0001224 | 0.00012242 |
| 0.00068817 | 0.00059262 | 0.00032451 | 0.00105183 | 0.00025392 | 0.00093136 |
| 0.00078499 | 0.00078859 | 0.00129513 | 0.00027486 | 0.00126373 | 0.00031344 |
| 1.08E-07 | -1.16E-07 | -0.0001579 | 0.00015815 | -0.0001473 | 0.00014709 |
| 0.00090004 | 0.00080539 | 0.00075629 | 0.00104378 | 0.00067153 | 0.0009393 |
| 2.49E-05 | 3.24E-05 | 9.49E-05 | -4.50E-05 | 9.76E-05 | -3.27E-05 |
| 1.67E-05 | 1.74E-05 | 0.00012321 | -8.98E-05 | 0.00011664 | -8.17E-05 |
| -8.94E-05 | -9.18E-05 | -0.0001349 | -4.39E-05 | -0.0001342 | -4.94E-05 |
| -0.0002364 | -0.000209 | -0.0001388 | -0.000334 | -0.0001181 | -0.0002999 |
| -5.25E-05 | -4.31E-05 | -0.0006606 | 0.0005556 | -0.0006095 | 0.00052323 |
| -4.03E-05 | -3.61E-05 | -9.11E-05 | 1.04E-05 | -8.34E-05 | 1.12E-05 |
| -0.0043182 | -0.0042611 | -0.0046653 | -0.0039711 | -0.0045844 | -0.0039378 |
| -0.0022796 | -0.0021015 | -0.0027178 | -0.0018413 | -0.0025097 | -0.0016934 |
| -9.58E-06 | -3.22E-06 | -0.0006321 | 0.0006129 | -0.000583 | 0.00057656 |
| -0.0002082 | -2.44E-04 | -0.0002998 | -0.0001165 | -0.0003291 | -0.0001584 |
| 0.00092168 | 0.00101103 | 0.00112591 | 0.00071745 | 0.00120125 | 0.0008208 |
| -4.81E-06 | -4.41E-06 | -3.56E-06 | -6.05E-06 | -3.24E-06 | -5.56E-06 |
| 2.92E-10 | 9.89E-09 | -6.03E-05 | 6.03E-05 | -5.62E-05 | 5.62E-05 |
| 2.09E-06 | 1.99E-06 | -8.34E-05 | 8.76E-05 | -7.77E-05 | 8.16E-05 |
| 0.00330809 | 0.00330248 | 0.00363881 | 0.00297738 | 0.00361051 | 0.00299445 |
| 0.0009639 | 0.00103239 | 0.00039379 | 0.00153402 | 0.00050138 | 0.00156339 |
| -0.0026353 | -0.0025437 | -0.003126 | -0.0021446 | -0.0030008 | -0.0020867 |
| 0.00160456 | 0.0016475 | 0.00117913 | 0.00202999 | 0.00125125 | 0.00204375 |

* 1. **Bayes Distinction**

In the distance distinction method above, it does not take into account the frequency of each sample in the whole, and does not take into account the loss caused by the wrong distinction. The Bayes distinction method modified on the basis of distance distinction, and the formula is as follows 29:



(29)

Among which represents a posteriori probability, represents a priori probability, represents the frequency at which the sample appears, and represents the total covariance matrix. The distinction rule is that the posterior probability is the highest and the average wrong distinction loss is the lowest, which brings out the rule is as follows: If the condition meets the following formula 30:



(30)

Then we categorize into , among which is the ensemble, is the probability density function of , is priori probability of , which is the probability that it belongs a certain category when sample occurs, and is the number of . The solution formula for distinction analysis is as the following formulas 31-32:

and

(31-32)



In this case, represents the condition probability of wrongly categorizing the sample of to the ensemble . is the loss caused by this categorization. is a division of a set of distinction samples. is the average wrong distinction loss. The solution to a Bayes distinction analysis is to make the smallest set of solutions.

Using the MATLAB program, we still randomly sample of the ensemble as a learning sample and as a test set to carry out Bayes distinction solution. We utilize the data after principal component analysis to study the condition of the distinction.

The result is shown in the appendix, part of which is as following figure 7-8 and table 20. For instance, the number “91” shows that there are 91 samples with 2G RAM are judged as click rate category 1.

Table 20: RAM result in click rate

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Category 1 | Category 2 | Category 3 | Category 4 |
| 0.125 | 2 | 0 | 0 | 0 |
| 0.5 | 7 | 0 | 0 | 1 |
| 1 | 49 | 0 | 1 | 7 |
| 1.5 | 1 | 0 | 0 | 0 |
| 2 | 91 | 0 | 15 | 25 |
| 3 | 41 | 1 | 64 | 19 |
| 4 | 1 | 13 | 68 | 2 |
| 6 | 0 | 11 | 22 | 0 |
| 8 | 0 | 0 | 1 | 0 |

Figure 7: Bayes Result of Recording Definition in Low Convert Rate

Figure 8: Bayes Result of Highest Camera Resolution in High Convert Rate

From the result given, we can clearly figure out the trend that the higher the mobile configuration is, the high click rate and convert rate the sample has. To be specific, phones with higher display resolution, higher recording definition, higher camera resolution, more CPU cores, larger RAM, and more spacious ROM are apt to reveal more satisfactory sales condition. The phones that displays weaker sales performance tend to possess lower counterparts of the features listed above.

* 1. **BP Neural Network Fitting**

We utilizes BP neural network fitting as another method to promote the accuracy of the regression. BP neural network works to encode itself with its high-dimensional features and to carry out dimension reduction processing towards high-dimensional data. It is marked by feature extraction model with unsupervised learning, which can also combine few basic features to obtain higher-layer abstract features.

We utilizes Tangent Sigmoid function as the transfer function; we use Levenberg Marquardt algorithm (trainlm) as the training algorithm; we use the Gradient descent with momentum weight and bias learning function (learngdm) as the learning algorithm; We use the mean square error (MSE) method as the learning function. The structure of the network and the performance plot is shown as following figures 9-10.



Figure 9: BP Neural Network Structure



Figure 10: the performance plot of BP Neural Network

We utilizes the properties after the Information Entropy analysis to conduct the process. Using the MATLAB program, we still randomly samples of the ensemble as a learning sample and as a test set to carry out the BP neural network fitting. We divide the learning samples in to five groups, each time using four of the groups to carry out a model and then test the test set. Therefore we can obtain five identical models, and then we use the BOOST algorithm to get the means of the five result. The result is in the appendix, part of which is as the following table 21.

Table 21: BP Neural Network Result



It can be seen that some of the predicted data runs an accuracy that is higher than 99%, which shows that this model can successfully reflect the trend.

* 1. **BOOST Algorithm**

We utilizes BOOST algorithm to obtain the average value of each methods of the samples. The formula is as the following formula 33

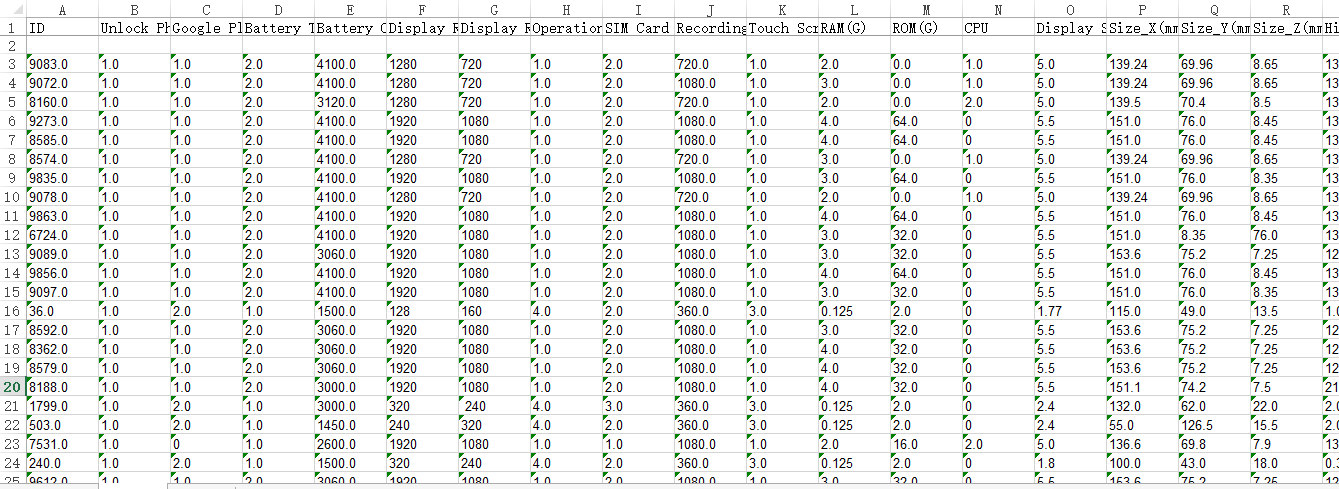
(33)

In the formula, denotes the original result of principle component analysis. denotes the result of Bayes distinction. denotes the original result of BP neural network fitting. For each categories in Bayes distinction, we utilizes the mid-value of each interval to numerate each category. We divide the click rate into 5 categories, which are 0-0.1, 0.1-0.2, 0.2-0.225, 0.225-0.3, 0.3-0.464, as well as the convert rate into 5 categories, which are 0-0.1, 0.1-0.2, 0.20-0.22, 0.22-0.23, 0.23-0.468. Therefore, we use 0.05, 0.15, 0.2125, 0.2625, and 0.382 to denote the 5 result of the categories. We use 0.05, 0.15, 0.21, 0.225, and 0.349 to denote the 5 result of the categories.

1. **Application**

We use the data which has exactly one zero of each data as the test sets and conduct the BP neural network illustrated in part 5 to obtain the final result to show that our models and methods can be applied to a broader range. We use the data after Information Entropy for BP neural network Fitting. The following table 22 is a part of the final result.

Table 22: Final Result



1. **Conclusion**
   1. **Sensitivity Analysis**

Sensitivity analysis is a method of studying and analyzing the sensitivity of the model to changes in system parameters or surrounding conditions. In our team's optimization methods, it can detect the stability of our model, especially when the given data is not accurate.

In this part we will mainly discuss the sensitivity of the application part. If we give the test set of the data an increase or an decrease of 1%, by changing the value of the original data matrix on the program, we discover that the output data of the principal component regression changes exactly 1%; almost all the results in the Bayes Distinction part have no change in categories; the majority of the output of BP neural network model fluctuates 1% approximately. The output after the change is small enough for us to make further adjustment. Therefore, it is acceptable in the modeling. This sensitive analysis also indicates that our model has universality and can be applied to more situations. For instance, if there is some error in the data, out final result does not vary rapidly correspondingly. Therefore, our model is relatively stable. The data of Sensitivity Analysis can be referred to the appendix part.

* 1. **Strength and Weakness**

The method we propose in the paper has effectively made up the vacancy and deficiency of the previous evaluating process regarding to the sale of the cell phone, and several main advantages are as the following. For a start, it presents the ranking of the most important individual variables within the cell phone market, the result of which are seldom considered by the manufacturers but actually of great significance. The manufacturers can take the specific traits of the phones into consideration and thus deciding which types or combinations of traits are more profitable to produce and fit the need of their target customers. Furthermore, as the application section in the paper indicates, the process we propose can also be applied for pragmatic purpose. By using the method linked with BP neural network, the process can successfully predict the outcome of the sale of the cell phones before they are released into the market, and the margin of error is within acceptable level. Besides the application of the evaluating process in the real life, the, the method itself is also more advanced and comprehensive than that in the previous thesis. For the method of information entropy in data processing and BP neural network in the optimization, they not only fit in the exact needs of the data being processed and the expected outcome, but are also more precise and reliable, ensuring the credibility of the model as a whole.

Admittedly, there are several shortcomings concerning the whole paper, like for some particular methods including Grey Relational Analysis, the results are not very desirable, and they are not quite useful for the later optimization. However, considering the methods being applied as a whole, the advantages and obviously outweighs the deficiency, thus making the modeling reliable for reference and have high practical value.

* 1. **Conclusion**

In conclusion, the paper yields significant results in the following four aspects. First, the method concerning AHP produces qualitative analysis of which specific traits in the individual variables promote the sale of the phones the best way. For example, regarding to the display resolution, target readers can clearly make out the third category as bringing more profit and contributing more to the sale. The results can be compiled into graphs and thus providing the whole picture in a straightforward way. Besides, AHP is an easily accessible method and produces relatively reliable result.

Second, the quantitative research can be used to rank the factors and determine which factors are the most crucial ones that the manufacturers should take into consideration. The results reflect the customers' tendency towards different types of cell phones, and their preference is carefully studied using information entropy in the data processing. The ranking of individual variables gives the target readers a broader view of which ones are the keys promoting the sale and lays the stepping stone for the further optimization relating to the different traits in individual variables.

Third, the optimization process allows the determination of specific characteristics that contribute to the highest sales volume. The optimization using Bayes distinction and BP neural network further explores the result in specific details. For example, as for the individual variable like color, it can be analyzed that gold contributes to the highest sale, the fact of which will definitely give the manufacturers more detailed references when making decisions about the production of certain cell phone. For other variables, the same method can be applied, either, yielding valuable insight to specific traits.

Last but not least, the sales volume of the cell phones can be successfully predicted applying the method in the optimization process, as mentioned in the application section. This enables the manufacturers to predict the sale with given characteristics and according to the sensitivity analysis and data testing, the model is reliable and can be applied for other practical uses.

1. **Reference**

Blablablablablablablablablablablablablablablablablablablablablablablablablablabla

1. **Acknowledgement**

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1. **Appendix**

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**此页开始为致谢页**

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