

Research on Accurate Recommendation of Personal Accident Insurance based on Actuarial Theory

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Abstract. This paper explores the development of a precise recommendation system for personal accident insurance grounded in actuarial principles. As societal needs for risk management and tailored services increase, the challenge of effectively recommending insurance products to specific customers has emerged as a pressing issue within the insurance sector. Initially, this study examines the context and importance of researching personal accident insurance, followed by an analysis of the accident insurance market to grasp the current state of recommendation systems. Additionally, it investigates how data and machine learning can facilitate accurate recommendations for insurance products. By gathering and evaluating historical data alongside customer behavior patterns and preferences, a personalized recommendation framework is established. This system aims to deliver customized insurance options based on various customer attributes such as age, gender, occupation, health condition, and individual needs for coverage—ultimately enhancing customer satisfaction. Findings indicate that an accurate recommendation system rooted in actuarial science significantly boosts the precision of personal accident insurance suggestions while offering a solid foundation for pricing strategies and effective marketing approaches for insurers. Looking ahead, with ongoing technological advancements and data accumulation, the role of actuarial science in refining personal accident insurance recommendations will likely expand further, providing robust support for sustainable growth within the industry.

Keywords: Accident insurance, recommend system, statistical analysis, actuarial science.

1. Introduction

The insurance industry plays an important role in the current advanced medical situation, especially in the field of personal accident insurance. As an important insurance product, personal accident insurance helps individuals and families to deal with the economic risks, which can reduce the economic burden and ensure the stability and safety of life. With the rapid development of science and technology, their accuracy is crucial to the development of insurance companies. Nowadays, the traditional ways mostly depend on experience and manual analysis, which has been difficult to cope with the complex and changeable market environment and meet people's personalized needs. Therefore, using methods such as recommendation system and actuarial models to optimize the accuracy of risk assessment has become an urgent problem for the insurance industry. This paper aims to discuss the application of recommendation system and actuarial in the insurance industry. Taking personal accident insurance as an example, the accuracy of risk assessment is improved by integrating data, machine learning and artificial intelligence technologies. At the same time, through in-depth study of the potential and role of recommendation system and actuarial in the insurance industry, this paper will provide insurance companies with ideas and methods to optimize risk assessment in personal accident insurance and promote the further development.

The findings presented in this paper hold considerable theoretical and practical importance. Firstly, by thoroughly examining the use of recommendation systems and actuarial methods in personal accident insurance, it contributes to offering more scientifically grounded approaches for recommending personal accident policies. Secondly, the outcomes of this research are expected to improve the competitive edge and adaptability of insurance firms, fostering innovation and growth within the realm of personal accident insurance. Lastly, this study also serves as a valuable reference for researchers and professionals in related disciplines, providing ideas for further investigating how intelligent technology can be applied within the insurance sector.

2. Literature Review

In recent years, domestic and foreign experts have conducted in-depth research on the development of personal accident insurance and give suggestions from both theoretical and practical levels, which has laid a good foundation for the development of the insurance industry in the future.

(1) Basic Principle and Research of Personal Accident Insurance

Lin Gang^[1] (2017) proposed the definition of "accidental injury" or "accident" in personal accident insurance and conducted in-depth analysis from different perspectives. He pointed out that the definition of "accident" in insurance terminology is much more rigorous and narrow than the "accident" understood in the market. It refers to "external, unexpected, unintentional and non-disease objective events". At the same time, there are usually two understandings of "accidental injury". From the overall understanding, the "accidental injury" defined in the clauses of the insurance contract has had a relatively complete interpretation, while the latter is divided and understood, there is an ambiguity about the word "accident". Li Jing^[2] (2021) believed that personal accident insurance is a kind of insurance, whose core lies in the fact that the insurer will pay the corresponding insurance money according to the contract when the insured suffers physical injury, disability or death due to sudden and unexpected accidents during the insurance period. The form of insurance reflects the spirit of social mutual assistance of "one for all, all for one" and is operated on the scientific basis of actuarial science. Fahri^[3] (2021) considers it as a way of risk transfer, transferring risks from one party to another, usually to the insurance company. In insurance, there are two parties involved, namely the policyholder and the insurance company. The policyholder is the party who receives compensation from the insurance company when the risk occurs; The insurer, on the other hand, is the party that provides compensation when a risk occurs. In short, insurance can be defined as the transfer of risk. One can think of it as a form of savings that can be used to absorb losses when risks occur. In the insurance industry, two interrelated parties are linked by an agreement that serves as a guiding principle between them

(3) Development Prospects and Existing Problems of Personal Accident and Injury Insurance

Scholars Yang (2015)^[4] that personal accident insurance small, slow development speed, single means of competition, insurance market disorder, and the personal casualty service level is low, so the author thinks that can enhance the innovation idea of personal accident insurance, speed up product innovation, strengthen the construction of information technology.

(4) Current Application of Accurate Recommendation System

Wang Hui (2023)^[5] believe that the traditional recommendation algorithm has obvious defects, and the classification accuracy can be improved by adding the feature word weighting improvement algorithm, and it is considered accordingly from the perspective of information gain. Su Zhan (2023)^[6] proposed a recommendation algorithm based on user similarity selection and tag distance, and conducted a verification test based on a real data set, showing that the proposed algorithm has high accuracy and scalability. Anupriya (2022)^[7] An in-depth discussion of how digital applications in life insurance companies are closely linked with attracting customers to patronage. She pointed out that in the context of the digital age, the quality online experience created by network benefits has become an important magic weapon for life insurance companies to attract customers. In order to accurately assess the website customers' preferences on the digital selection criteria, she adopted the best-worst method, which provides clearer guidance for customers in the decision-making process by comparing the advantages and disadvantages of different options. In addition, in order to more comprehensively study the impact of digital application on the life insurance industry, four representative life insurance companies, LIC, SBI Life, HDFC and Max Life Insurance, were also selected to conduct the alternative choice analysis of the scheme. This cross-company research approach not only enriches the research content, but also makes the research results more intuitive and easy to understand. By comparing the digital application strategies of different companies, she further revealed the universality and difference of digital applications in the life insurance industry, and provided valuable reference experience for other companies in the industry.

To sum up, in the period of rapid development of the insurance industry, although the research on actuarial principles, pricing principles and development prospects of personal accident insurance has achieved some results, the research on the application of recommendation system in the insurance industry is still insufficient. There is relatively little research on how to use precision recommendation system to improve service quality and customer satisfaction in the insurance industry. In the current digital context, recommendation systems have been widely used in many fields to improve user experience and marketing efficiency through personalized recommendation. However, in the insurance industry, especially in the field of personal accident insurance, the application of precise recommendation system is still in the exploratory stage. Therefore, this paper intends to conduct an in-depth study on the application of recommendation system in the insurance industry, collect relevant data of the insurance industry, analyze the demand and behavior characteristics of customers in the current insurance market, and build an accurate recommendation system suitable for the insurance industry. On this basis, this paper will further analyze the application effect of recommendation system in insurance product recommendation, customer service optimization and other aspects, and put forward corresponding optimization strategies and suggestions. Through the research of this paper, it is hoped that it can provide useful reference for the digital transformation and intelligent upgrading of the insurance industry. At the same time, this paper also hopes to provide more accurate and efficient marketing means for insurance enterprises, improve customer satisfaction, and promote the sustainable and healthy development of the insurance industry.

3. Market Analysis of Accident Insurance

3.1. Application Scenario Analysis and Sorting of Recommendation System

3.1.1 Application scenario analysis

This section will be analyzed from the perspectives of individual customers and enterprise customers.

(1) Match of the individual customer's insurance needs

For individual customers, the accurate recommendation system makes accurate recommendation of insurance types according to the customer's age, occupation, health status, family structure and historical insurance purchase records, and at the same time consider the actual insurance needs of users. In this paper, taking Jiangsu Province as an example, in the official data released by Jiangsu Bureau of Statistics, the income and compensation situation of accident insurance from 2018 to 2023 are selected to draw Figure 1.

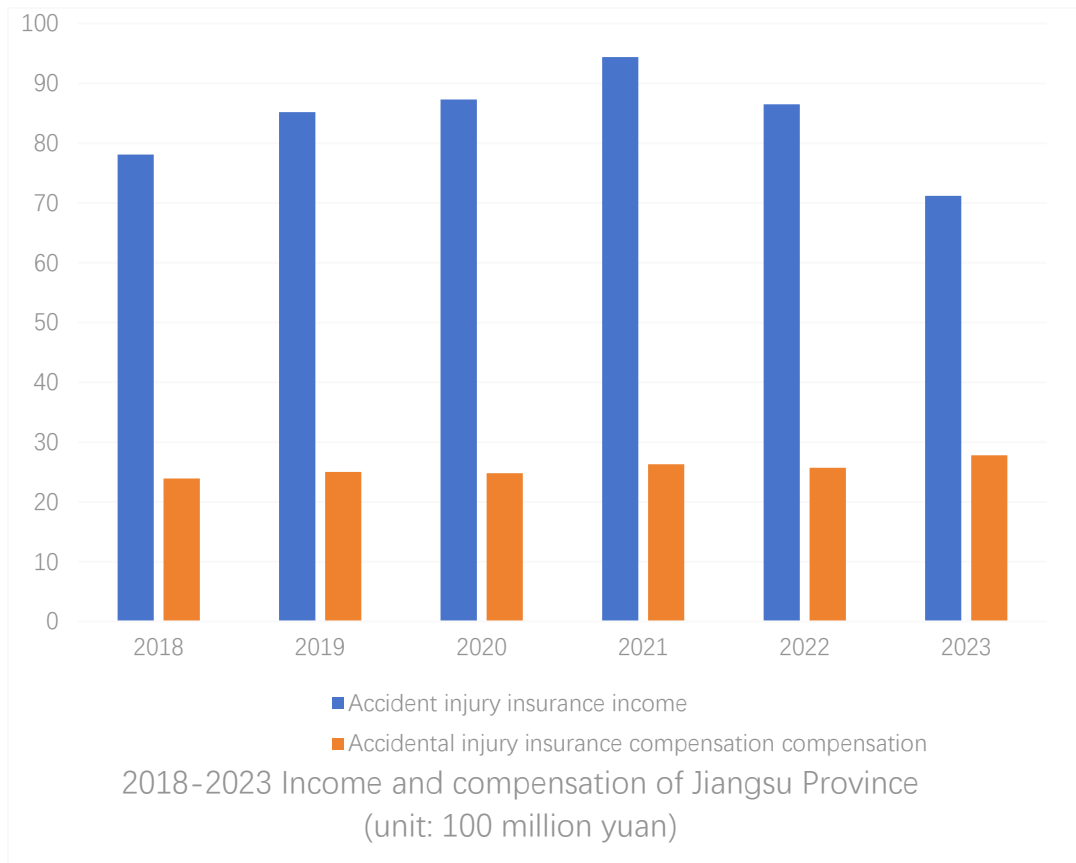


Table 1 Source: Jiangsu Province Statistical Bulletin on National Economic and Social Development

As can be seen from Figure 1, the total amount of accident injury insurance in Jiangsu Province increased from 2.5 billion yuan to 2.78 billion yuan. Although there were fluctuations in the middle, the overall compensation showed an upward trend. This data shows that residents in Jiangsu Province are in increasing demand and awareness of accident injury insurance, and also reflects that insurance companies pay more attention to accident injury insurance. At the same time, the growth rate of compensation fluctuated significantly during this period, from 4.7% in 2018 to 40.3% in 2020, and then to 9.3% in 2021, until 7.9% in 2023. Such volatility may be affected by a variety of factors, such as economic development status, market conditions, and consumer preferences. Although the total amount of compensation is increasing gradually increased, the proportion of accident injury insurance in the total compensation is relatively stable, about 2%. This shows that the position of accident injury insurance in the whole insurance industry is relatively stable. With the development of society and the improvement of living standards, people's risk awareness is gradually enhanced, and they begin to pay more attention to personal safety and risk protection. Under this background, the accidental injury insurance has been concerned about and favored by the public because of its ability to cover the daily accidental injury. Different groups of people have diversified demands for accidental injury insurance. Young people tend to pay attention to the risks such as sports injuries and traffic accidents, while the elderly pay more attention to the protection of the risks such as falls and fractures. Insurance companies should adapt to the needs of The Times and the personalized needs of citizens, launch more targeted insurance products and precise recommendations, provide more convenient services, and further improve customer satisfaction. However, consumers still maintain a certain sensitivity to the price when buying insurance products, so insurance companies also need to seek a balance between the guarantee of quality and price, and provide cost-effective insurance options. Consumers have different demands for accident insurance, so they need to make these choices according to their own needs and characteristics, including age, gender, travel frequency, etc. The

frequency of personal accident insurance is not the same, which mainly depends on the likelihood of accident risk.

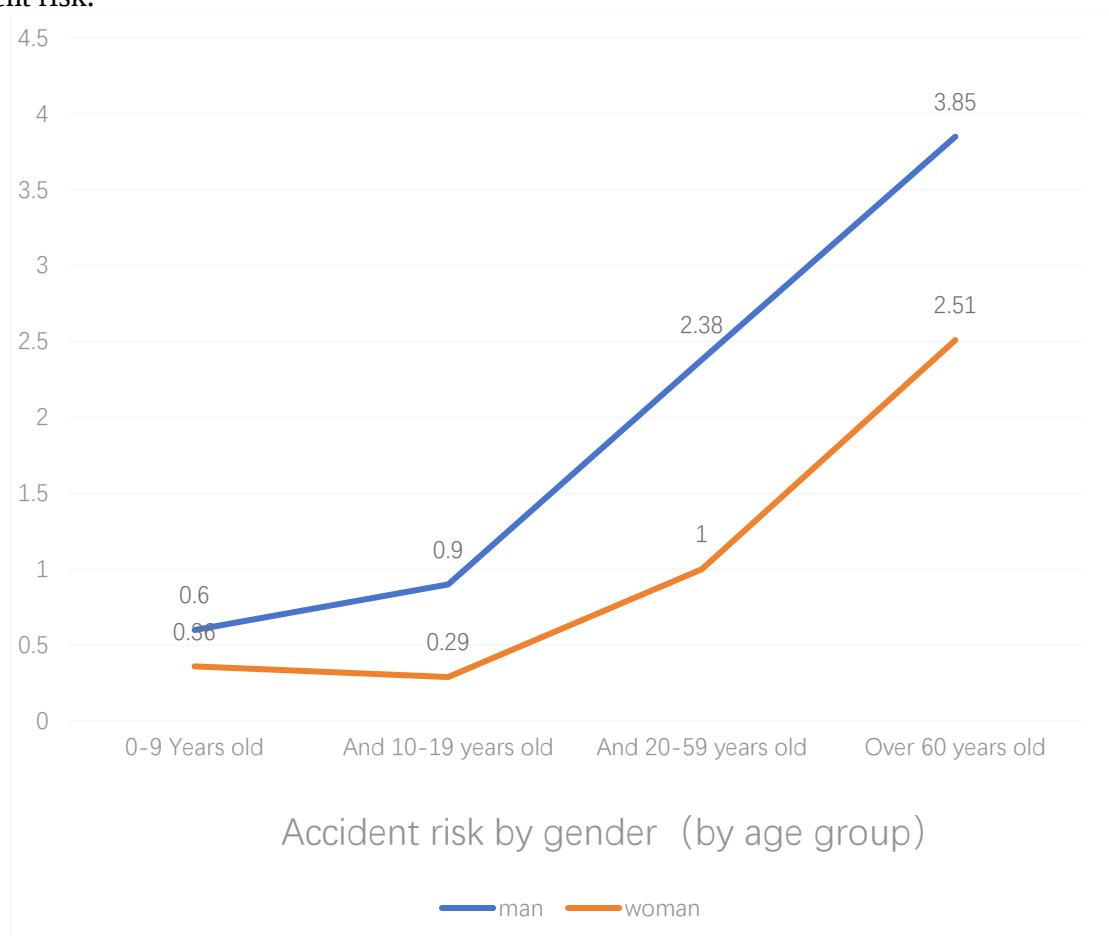


Table 2 Source: Research Report on Accidental Injury Risk of Chinese Insurance Population

Figure 2 shows that the unexpected risks faced by men and women show different trends with increasing age. First, for men, the accident risk reached a high level from the 0-9 years age range, followed by a slight increase in the 10-19 years age range, and then a peak of 3.85 in the longer 20-59 years age range, the highest of all ages. It may be because men in this age group are more involved in social activities and work and thus face more potential risk. However, after entering the age group over 60 years, the unexpected risk of men began to decrease significantly, which may be related to reduced higher risk activities in older men or more emphasis on personal safety.

In contrast, the unexpected risk in women remained relatively stable across the age range. From the 0-9 age range, the risk was slightly lower for women than for men, and then in the 10-19 and 20-59 age groups, but remained lower than for men. The risk of accident until women over 60 increased slightly, but still lower than men of the same age. This is closely related to women's tendency to engage in safer activities and the higher social attention to women's safety.

In conclusion, men face the highest unexpected risk in the age range of 20 – 59 years, while women maintain a relatively stable lower risk throughout the age range. Therefore, when formulating insurance strategies, personalized insurance plans should be formulated according to the risk characteristics of different age groups and different genders to meet the needs of different groups.

(2) Enterprise Consumer Risk Management and Guarantee

From the perspective of the enterprise, buying accident insurance for employees is an important measure to protect the rights and interests of employees. When choosing accident insurance, we need to choose the appropriate type of insurance according to the actual needs of employees and market trends of employees. Considering the age, occupational characteristics and the risks they may face in the working environment, accident insurance may cover a variety of risk scenarios. For young people, they may pay more attention to high-risk scenarios such as sports injuries and traffic accidents, so

they can choose accident injury insurance products with high medical expense reimbursement, disability compensation and emergency rescue services. For older employees, risks such as falls and fractures are more common. Therefore, attention should be paid to insurance products including fracture allowance and rehabilitation expense reimbursement. At present, in addition to buying the necessary five social insurance and one housing fund, enterprises usually buy group accident insurance for employees to ensure that employees can be fully guaranteed and timely assistance when they suffer from accidental injuries.

Based on the in-depth analysis of the above application scenarios, we can clearly see the important role of recommendation systems in the insurance industry. Next, we'll explore why these systems are necessary for the industry to grow and improve customer satisfaction.

3.2. Necessity Analysis of the Recommendation System

This study explores the application value of the precise recommendation system of personal accident insurance based on actuarial principles, constructs detailed customer portraits through the personal information and preference data of mobile phone customers to deeply insight into customer needs, and ensures the accuracy and timeliness of product information. The recommendation system can effectively design and optimize the recommendation algorithm based on user portraits and insurance product library, screen out the insurance products that best meet customers' needs, and provide personalized solutions to improve the sales efficiency of insurance products and customer satisfaction.

4. Analysis of Accident Insurance

4.1. Personal accident insurance supply analysis

As of September 1,2023, there are 94 life insurance companies in China, and most of these companies will provide personal accident insurance as one of their main businesses. Although the number of insurance groups and holding companies is small, they usually cover personal accident insurance business, especially large comprehensive insurance groups. In terms of regional distribution, life insurance companies are mainly distributed in Beijing, Shanghai and Guangdong (mainly Shenzhen), with the three regions together accounting for 70.5%

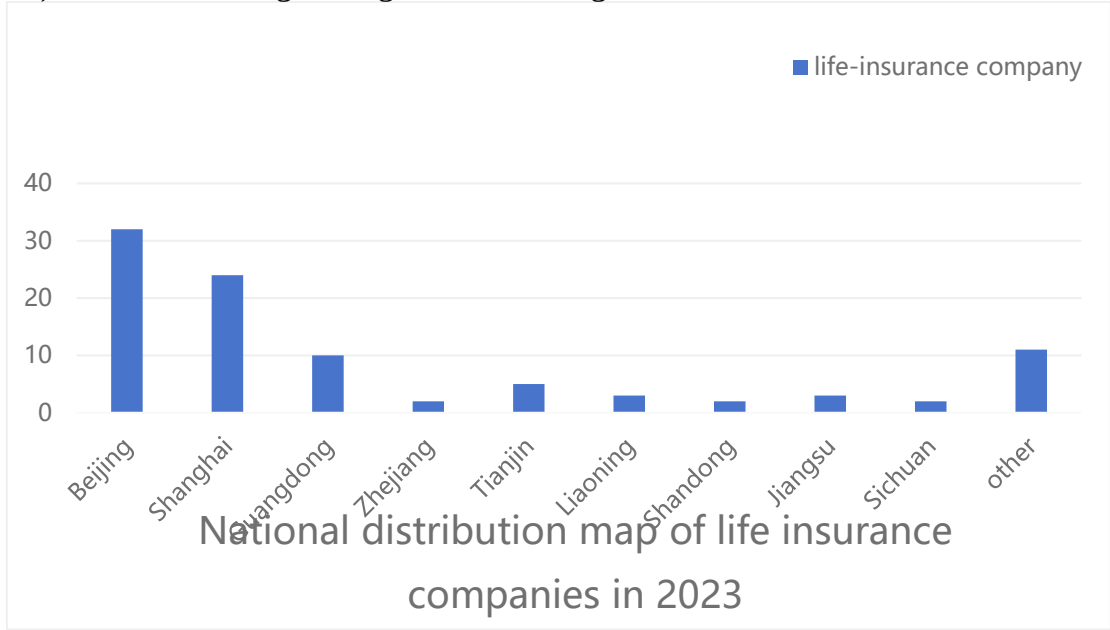


Table 3 Data Source: State Administration for Financial Supervision

At present, there are 13 insurance groups or insurance holding companies in China, 12 insurance groups and 1 holding company, all of which are registered in Beijing, Shanghai and Shenzhen, including 9 in Beijing and 2 each in Shenzhen and Shanghai.

4.2. Analysis of Individual Cases of Large Personal Accident Insurance Companies

AIA is the world's largest independent listed life insurance group in pan-Asia, operating in 18 markets in the Asia-Pacific region. The high payment of AIA is a major feature of its insurance. According to the compensation data of the first quarter of the first half of 2024, AIA Life ranked third, with a comprehensive repayment rate of 233.98% and a core repayment rate as high as 389.82%. At the same time, the high loss ratio is also a sign of AIA, with a solvency adequacy ratio of 335% in 2023, which is significantly higher than the industry average. A high solvency adequacy ratio means that AIA has a strong financial strength and risk resistance ability to provide customers with more stable and reliable services. This is also one of the important factors in AIA's leading position in the insurance industry.

At present, the main business of AIA insurance company is life insurance and financial management insurance. For personal accident insurance, the main categories are:

Personal accident injury insurance: to protect the physical injuries suffered by customers in accidents, including medical expenses, hospitalization allowance, disability compensation, etc. The price varies according to the customer's age, occupation and other factors, generally between a few hundred yuan to thousands of yuan.

2. Children's accident insurance: specifically for children, including accidental injury, disease, etc. The price is relatively low, generally between dozens of yuan to hundreds of yuan.

3. Travel accident and injury insurance: to protect the accidental injuries suffered by customers during the trip, including medical expenses, emergency medical transfer, accidental death, etc. The price varies according to the travel destination, travel time and other factors, generally between tens of yuan to hundreds of yuan.

4. Driving accident injury insurance: guarantee the accidental injuries suffered by customers in driving vehicles, including traffic accidents, train accidents, aircraft accidents, etc. The price varies according to the customer's age, driving age and other factors, generally between dozens of yuan to hundreds of yuan.

The author selects the more popular AIA Xin Anyi (2023) accident insurance for individual case analysis

(1) Comprehensive guarantee and comprehensive coverage

AIA basic insurance covers general accident death and disability protection, air accident death and disability protection, in which air accident can double doubled, but also provides five optional responsibilities for consumers to add. Basic insurance covers general accident death and disability insurance, air accident death and disability insurance, in which air accident can double the compensation, but also provides five optional responsibilities for consumers to add. It can be seen that AIA has comprehensive coverage and high loss rate.

(2) The compensation range is wide and fast

Accident insurance covers a variety of accidental injuries, including traffic accidents, drowning, fire, electric shock and other accidents. In the event of an accident, the insured or his or her family members only need to timely report the case and provide relevant certification materials, and AIA will quickly start the claim settlement procedure. The insurance company will investigate and verify the accident, and pay the insurance benefits as soon as possible after confirming the authenticity of the accident and the identity of the insured. In addition, AIA also provides 24-hour online customer service and telephone consultation services to facilitate the insured to consult and understand the progress of claims settlement at any time.

(3) Low insurance premium and high guarantee

It has super cost-effective, the cheap premium and the high insurance amount.

(4) Emergency rescue services

Some accident insurance products of insurance companies also provide emergency rescue services, such as travel accident insurance, which can be accidents during travel.

(5) Wide audience

Support the age of 7 days-60 people insured, the insurance period is one year, suitable for all ages, can meet the insurance needs of most people.

To sum up, AIA Anyi (2023) accident insurance has the characteristics of low premium, high guarantee, fast claim settlement speed and comprehensive guarantee coverage compared with the products launched by other insurance companies.

5. Recommend the Design Problem of the System Model

5.1. Concept and Technology of the Recommendation System

K- means clustering algorithm is a widely used unsupervised learning algorithm, and its core thought is by means of iteration point distribution of the data set into K clusters, making each point to its place the center of the cluster of minimizing the sum of distance. The specific algorithm is to gather the n objects in the data set into the specified k clusters according to the similarity between the objects, and the distance between each object and the center of the cluster is the minimum.^[8]

Firstly, K data points in the data set are randomly selected as the initial cluster center. For each point in the data set, its distance from each cluster center is calculated, and it is classified into the cluster represented by the nearest cluster center. Second, the cluster center of each cluster is recalculated, usually the mean of all the points within the cluster, as the updated cluster. Finally, the above steps of cluster allocation and cluster center updating are repeated until the cluster center no longer changes, the change is less than a predetermined threshold, or the maximum number of iterations is reached.

K-means algorithm shows high efficiency in processing large-scale data sets, especially when the data dimension and the number of clusters are not very large, and it has a wide range of applications in many fields, such as market analysis, image processing, document clustering, etc., and is suitable for various types of data. And K-means algorithm may extend by way of parallel computing, etc, to adapt to the larger data processing requirements. Through the K - means algorithm, can explain and understand each cluster has its corresponding cluster center, through cluster center to understand the common features of the data points within the cluster.

5.2. Recommendation of Customer Groups and Personalized Insurance Products

In the construction of personalized accident insurance product recommendation system, the author first collects customer information in the form of questionnaire, including basic information such as age, gender, occupation, income level and family status, as well as auxiliary information such as historical claim records, medical files and social and economic data. Data cleaning process, through strict remove outliers, to ensure the accuracy and consistency, are integrated to a unified data warehouse. Then, the K-means cluster analysis method is used to set the customer feature data set as the insurance feature data set as where

$$C = \{x_1, x_2, x_3 \dots x_n\}, \quad M = \{y_1, y_2, y_3 \dots y_m\}$$

Moreover, x_i represents the feature vector of the KTH customer. It includes age, gender (which can be coded as 0/1), occupational risk level(quantitative score), income level (segmented code), family status (such as the number of children, marital status and other quantitative indicators), historical claim records (such as the number of claims, average payment), health status score in medical records and economic data. Furthermore, insurance have m features, defined as the relationship of insurance features with the customer for Y_{ij} , said the consumer features and the JTH insurance feature.

Firstly, the data is cleaned to remove outliers and ensure the accuracy and consistency of the data. Based on factors such as age, gender, occupational risk level, health status and living habits, the customers are divided into different groups, such as young healthy group, high-risk occupational group and elderly retirement group. Then, to design a specific number of accident insurance products, such as suitable for low risk accident insurance, the basis of young group facing the high income, high risk group of high-end accident insurance (including high pay and global rescue services), and focus on the old fracture, fall risk of elderly special accident insurance. The random forest machine learning algorithm is used to construct a pricing model based on customer cluster characteristics, historical claim data, regional and industry risk levels and macro economy to achieve accurate pricing.

Then, through the K-means clustering model, all clusters are classified and integrated. The goal is to minimize the sum of squares of the distance between all points and the center of the cluster to which they belong. Consequently, customer similarity is defined as:

$$S_{kk'} = \sqrt{\sum_{i=1}^n (x_{ik} - x_{ik'})^2}$$

6. Conclusion

In this paper, we deeply discuss the research of personal accident injury insurance pricing and accurate recommendation system based on the principle of actuarial science, aiming to provide more personalized and accurate insurance services for customer groups with different characteristics through scientific methods and advanced technical means. Through systematic analysis and empirical research, the author found that actuarial science plays a vital role in the pricing of personal accident injury insurance. Secondly, the introduction of big data and machine learning technology provides strong support for the accurate recommendation of insurance products. By collecting and analyzing customers' historical data, behavior patterns and preference information, we can build a personalized recommendation model to provide customized insurance schemes and premium quotations for customer groups with different characteristics. This precise recommendation method not only improves the market acceptance of insurance products, but also promotes the digital transformation and intelligent upgrading of the insurance industry. To sum up, the personal accident insurance pricing and accurate recommendation system based on actuarial science principle has significant advantages and broad application prospects. It can not only improve the pricing efficiency and recommendation accuracy of insurance products, but also meet the personalized needs of customers, improve customer satisfaction and the market competitiveness of insurance companies. In the future, with the continuous progress of technology and the continuous accumulation of data, we have reason to believe that the research in this field will achieve more fruitful results and inject new vitality into the sustainable and healthy development of the insurance industry.

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