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A Hybrid Neuro-Fuzzy Network for Underwriting of Life Insurance

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Abstract: This paper is a study of life insurance underwriting for individuals and the various processes involved in providing cover to the insurance seeker. Underwriting is the process of classification, rating and selection of risks among the diverse insurance applications. The paper explores various steps taken in insurance underwriting to rate the insurance application, the various risk factors considered for taking an insurance underwriting decision and proposes a model for insurance underwriting. A robust method for automating the underwriting process through the hybrid methodology is presented, which comprises of Neural Network and Fuzzy Logic. Neural Network in the proposed model can be trained to traditionally perform the insurance underwriting for individuals, while the fuzzy rules are expected to take care of the fuzzy inputs.
An insurance application is compared against various pre-defined standards and is classified into one of the risk classes. Based on the risk classes, the premium to be paid by the applicant is determined - higher the risk class, higher is the premium. The application of Artificial Neuro-fuzzy Network in insurance underwriting process can considerably reduce the time and insurance losses.

Keywords: life Insurance; mortality; risk; premium; underwriting; neuro-fuzzy network.

I. INTRODUCTION

Insurance in the broadest sense include methods of transferring risk to insurance companies. Being the legal entities, the insurance companies cover the financial impact or part of it that derives from the occurrence of certain unexpected events affecting the insured. This benefit is offered in exchange for payment of a predetermined amount of money called premium. Any risk which can be quantified can potentially be insured and covered.

Traditional insurance underwriting is a complicated process of classification, rating, and selection of risks. In simple terms, it's a risk selection process wherein the risk to the insurance company is considered while providing cover in the light of various health related factors like the individual's age, current state of health, medical history, lifestyle etc. This selection process evaluates all the available information to determine how an individual will be classified and his chances to have a standard or substandard risk. After this classification procedure is completed, the policy is rated in terms of the premium that the applicant will be charged. The policy is then issued and subsequently delivered to the insured by the insurer.

An underwriter is a professional who employs sound judgment based on his knowledge and experience to read beyond the basic facts, and gets a true picture of the insurance seeker's lifestyle to understand the risks to which he is exposed to. An Insurance underwriter is basically hired by insurance company to analyze the application for insurance and to take the decision whether to accept or reject the application. In case the application is accepted, what premium the company would charge for the insurance policy is also decided. The underwriter looks for factors such as occupation, dangerous hobbies, etc. that could make the applicant more likely to die before his or her natural life expectancy, or reasons to anticipate that the individual may become ill or involved in an accident that will create high medical expenses. Underwriters not only calculate the right risk for the individual, but also protect the insurance companies against adverse selection.

In assessing the most appropriate risk, underwriters work closely with the specialists called actuaries; who practice the collection and interpretation of numerical data; and use statistics to calculate insurance premiums. The actuaries analyze important data such as mortality, sickness, injury and disability rates and use such information to aid those involved with insurance. They are responsible for collecting the data to forecast future risks and see how these predictions affect various aspects of insurance. As of 1981, computers were not considered important to the underwriting process. Leading experts in insurance underwriting believed that the human-judgment factor involved in the insurance underwriting process was too complex for any computer to handle as effectively as a human underwriter [1]. The calculation of insurance or risk premiums has been an essential and active topic in actuarial literature, which has attracted the attention of actuaries such as Buhlmann and Goovaerts, Vijlder & Haezendonck ([2],[3]). Recently, modern theory of risk and economic choice under uncertainty has played an important role in studying insurance premium calculations ([4],[5],[6]). Hurlimann [7] makes a brief, yet comprehensive summary about the development of insurance premium calculations. He emphasizes desirable and reasonable properties that insurance premiums should satisfy. Research in the application of technology to the underwriting process has shown that Holtom's statement may no longer hold true ([8], [9]). The time has come for intelligent systems to take-on the important role in the insurance underwriting, decision

making and traditional task of calculations. An effort is made to suggest a model with the applicability of Fuzzy Neural Networks in insurance underwriting considering the fact that the real world is full of vagueness and uncertainties. The model is based on following assumptions:

a. The underwriting process is carried out only for individual insurance.
b. All the risks behave in a homogeneous manner.

The model considers only those portfolios which have homogeneous risks, or at least if there is a sufficiently large number of similar risks and these are treated as one portfolio. In practice companies do accept risks with different risk profile but they are treated differently like charging extra premium and applying waiting periods to restore the necessary risk in the portfolio. The paper is organized as follows: In Section 2 the research work done so far in insurance using various methods is discussed. Section 3 discusses the concept and types of insurance. In Section 4, the process of insurance underwriting is delineated. In Section 5, the proposal of Neuro-fuzzy approach in insurance underwriting is presented while Section 6 describes the results expected from the proposed model in response to an insurance portfolio. Section 7 is devoted to the work that can be done on this model in future and Section 8 concludes the paper with the model's possible applicability in insurance sector.

II. RELATED WORK

In recent years**,** researchers have considered application of computers to the process of insurance underwriting. The application of a neural network had been described by Collins, Ghosh & Scofield [10] to replicate the decision-making of mortgage insurance underwriters by training the system on a database of certified cases. The recent use of Artificial Neural Networks represents what may result in the most accurate application of computers in the underwriting process. Fuzzy Set Theory has been successfully applied in insurance price problems that require much actuarial subjective judgment and those for which measuring the embedded variables is difficult [11]. Originally developed in the 1940′s, Artificial Neural Networks were designed to replicate and study the thought process of the human brain by Cowan & Sharp [12].

Bakheet used the back-propagation form of the feed forward NN as the pattern classification tool in construction bond underwriting [13]. Vaughn, Ong & Cavill used a multilayer perceptron network to classify applicants for whole life insurance into standard and non-standard risk [14]. They then used a knowledge discovery method to identify the significant, or key, inputs that the network uses to classify applicants. The inequity of the current rate classification system provide neural networks the opportunity to more accurately assess the risk level of each and every individual policy holder, rather than a class of policy holders [15]. A study was designed by Kitchens, Johnson & Gupta [16] to predict losses on automobile insurance using Artificial Neural Networks. Brockett, Xia & Derrig [17] used a kohonen self-organizing feature map (SOFM) to uncover automobile bodily injury claims fraud in the insurance industry and a feed forward Neural Networks using a back propagation algorithm to validate the feature map approach.

It has been over 20 years since the first article on fuzzy logic has been applied to insurance. Lemaire [18] applied fuzzy logic to underwriting and reinsurance decisions. Young [19] used fuzzy sets to model the selection process in group health insurance. Young [20] described how fuzzy logic can be used to make pricing decisions in group health insurance that consistently consider supplementary data, including vague or linguistic objectives of the insurer, which are ancillary to statistical experience data. Horgby, Lohse & Sittaro [21] provided underwriting with the application of fuzzy logic to the medical underwriting of life insurance applicants. De Wit G. W. [22] made an attempt to analyze the internal logic of intuitive part of underwriting by means of fuzzy set theory.

A number of softwares for Insurance Underwriting are available in the market. The All Lines Expert Underwriting System (ALEXUS) takes applications for insurance as input, and referred electronically to an underwriter based on authority level only if a risk characteristic has failed an edit. Applications are accepted by passing all edits, or by underwriter review and acceptance, and are automatically transferred to a policy issuance system. Acceptance/rejection criteria or rules are created and maintained in the system by the underwriters. Phoenix comprising of five functionally-rich modules viz. underwriting, broking, claims, reinsurance and accounting can be used independently or as a robust insurance platform.

Recently in May 2011, a software has been launched by L&T Infotech called AccuRUSI which enables better identification and evaluation of risk exposures, alignment of pricing and terms to the quality of risk, and improved underwriter productivity. It is claimed that by this insurers will be empowered to reduce their loss ratios and improve underwriting outcomes. Oracle Insurance Insbridge provides next-level business user empowerment to further ease insurance rate development and maintenance from a single system. Actuaries, product managers, underwriters, and business analysts can create, test, and deploy complex rating, rules and underwriting logic without programming expertise. With insurance underwriting software from Pegasystems insurers can quickly and easily deploy intelligent automated processes that drive efficiency, consistency, and compliance across the enterprise.

III. INSURANCE REVISITED

Insurance premium is basically the financial cost of obtaining an insurance cover, paid as a lump sum or in installments during the duration of the policy by insured. It can be calculated in two ways:

a. Value of service method in which the premium according to the utility of insurance to each proponent which cannot be used due to its impracticability.
b. Cost of service method in which the premium is charged according to the cost (include all expenses and profit margins) to the insurer.

Insurance premium is categorized into two classes viz. net premium which makes provision for mortality losses only or the premium which is received to pay the amount of claim whenever it arises at death or at maturity or surrender. It does not provide for expenses of management and gross premium which is charged by the insurer to meet the amount of claims and expenses. Thus gross premium includes the net premium and loading.

There are basically three types of insurance: Term life insurance provides coverage for a specific period or term often for 1, 5, 10, 15 or 20 years. If death occurs during the term, the policy pays cash benefits to the beneficiary. However, once the term is over, and if the policy is not renewed, the coverage ceases. If death occurs after the coverage ceases, no cash benefits are paid out. Whole life insurance covers the policyholder for his whole life. Unlike term insurance, there is no fixed end date for the policy. When the policy holder dies, the face value of the policy, known as a death benefit, is paid to beneficiaries. The cost of a whole life insurance policy is spread out across many years, so the premium remains the same. Endowment is the most popular life insurance plan, which combines risk cover with the savings and investment. If the policy holder dies during the policy time, he gets the assured amount. Even if he survives, he receives the assured amount. The advantage of this policy is, if the policy holder survives after the completion of policy tenure, he receives assured amount plus additional benefits like Bonus, etc. from the insurance company. In this kind of policy, the policy holder receives huge amount while completing the tenure. The cost of such a policy is slightly higher but worth its value. It is determined what constitutes a claim; death, survival or surrender and also when the claims are paid; at the beginning of the year, at the end of the year or during the year.

IV. INSURANCE UNDERWRITING PROCESS

In a typical scenario, the insurance underwriting process begins when an application is received by the insurance company for taking up insurance. The underwriter goes through the supporting documents either online or otherwise; and checks the document's availability and validity. If required, he can request additional information from the applicant and then rates the risk of insuring the individual by applying his knowledge and experience which sometimes may lead to inaccurate rate classifications. The process becomes more troublesome and time-consuming due to voluminous underwriting documents.

With the advancement of technology and automation of the underwriting process; the benefit is realized to have faster and accurate decisions limited to the availability of sufficient information. A fuzzy logic rule engine was designed and developed to codify the underwriter rules [23]. This digital underwriter is able to determine whether an application should be sent to a human underwriter for review or the automated process can be deployed without worrying about possible case variations.

The process which can be followed for scrutinizing, development and deployment of each insurance application is; inspection of the information provided by the applicant, knowledge acquisition from underwriter manual and review of guidelines, formation of underwriting rules, reviewing rules with experts, transformation of guidelines into fuzzy rules, training Neuro-fuzzy network on atleast 500 applications with sufficient variations, reviewing results with experts and rule updation if required, testing on around 40 more examples and finalizing the network training.

A. Risk Factors:

The risk factors are classified into categories like personal risk factor consisting of age, gender, height, weight, occupation, hobbies, aviation activities, driving history, international residence, family size and family background; medical risk factor consisting of health history including diabetes history, heart disease history and habits factor consisting of tobacco, smoking habits and drinking habits and lifestyle factor like exercise and eating habits.

Mortality rates are charges incurred by an insurance carrier to cover the risks in case of any eventuality to an individual. The mortality expenses differ depending on the age and the sum assured being availed by the insurance seeker. Premium is related to mortality rate in following sense:

i. Premium increases with the age of the insurance seeker.
ii. Premium increases in co-relation to hereditary or lifestyle ailments such as diabetes, hypertension, obesity etc.
iii. Premium increases by availing higher sum assured by an individual.

B. Risk Classification:

A risk class is a group of insured defined according to the mortality rates that represent a similar level of risk to an insurance carrier. Mortality rate, for life insurance, is the probability that a person will die at a given age. The higher the mortality rate, the higher the benefit cost and the higher the premiums for life insurance. The underwriter evaluates the degree of mortality rate from various factors. Mortality rates help to classify the risk in classes as shown in Table 1.

Table 1. Risk Classes

Class	Anticipated Mortality	Degree of Risk	Reason	% of Applicants	Premium Charged
Super Preferred	Almost nil unless any unpredictable event occurs	Least	No health impairments besides usual illness	25%	Least
Preferred	Lower than average	Very less	Few health impairments recently	60%	Less
Standard	Average	Less	Minor health impairments during the lifetime	10%	Average
Substandard	Higher than average	High	More than minor health problems	3%	High
Rejected	Highest	Very high	Impairments and anticipated mortality are too great to be affordable	2%	Highest

V. NEURO-FUZZY NETWORK FOR INSURANCE UNDERWRITING

Artificial Neural Networks were first developed in 1940′s as a mathematical model used to study the human thought process (Cowan & Sharp, 1988). While considering the portfolios for possible insurance, the underwriter has to confront with lot of uncertainties in the inputs given by the prospect. A Neuro-fuzzy system can best deal with such imprecise inputs by taking up the entire burden from underwriters to refer the risk assessment manuals. The unique abilities of a Neuro-fuzzy system can improve the underwriting process.

A. Insurance Underwriting Proposal:

From the financial view point, the insurer collects premium from the insured for covering the risk. This premium is used to pay underwriting expenses and to set up the necessary reserves to pay future losses. As an industry rule-of-thumb, the average pure premium is approximately between 57-60%. The rest of the collected premium is used to pay operating expenses and a small profit whose distribution varies from company to company. The allocation of premium that is observed by us is as given in table 2.

Table 2. Allocation of costs in Premium Calculations

Costs	*Percentage*
Pure Premium	57%
Development Factors	04%
Trend Factors	03%
Acquisition Costs	15%
Administrative Expenses	19%
Profit	02%
Total	**100%**

The list of expenses is far from complete. Premium also needs to be allocated for reinsurance expenses, unallocated loss adjustment expenses and taxes including premium tax, corporate income tax, and license or other fees.

The process starts when an application comes from an insurance seeker for possibly acquiring life insurance. As the very first step, the cost of insurance rates (COI) for the company is calculated. COI is the cost incurred by insurance company for providing insurance to an individual. The total amount charged by insurer as premium is the sum of COIs and expenses, including all the expenses shown in table 1. COI is calculated on per unit basis. One unit is usually ‘1000 units of face amount e.g. Rs. 10,00,000 = 1000 units. Based on all above discussed risk factors and medical examination, the risk classification is done. For both genders male and female, insurance is given between 0-85 years of age but the premium charged is different for the same age for both the genders. COI goes up with the age of insured because as the insured grows older, the risk to the insurer also goes up. COI is calculated by the companies based on the attained age of insured.

Table rating is given in 16 different categories e.g. from A (0.25) to P (4.0) with a jump of 0.25 units. Many portfolios may fall in the same risk class despite of disparity in their risk factors. Table rating is a means of additional risk classification so as to take into account the said disparity in risk factors within a given risk class. It is applied only on standard and sub-standard classes and it’s a multiplier to COI. The next step is to employ flat rating which is applied to all the risk classes. There are basically two types of flat ratings: temporary flat which is applied for fixed number of years and then it stops; permanent flat which is constant for all the years. Temporary flat is applied in those cases where the risk of the insured is assessed to be more for some initial years and then the possibility of losses decrease depending on the insured’s profile. On the other hand, permanent flat is applied in those cases where the chances of decrease in risk of insured are too less either because of his occupation or because of his hobbies. Once the decision of flat is over, fixed charges incurred by insurer for providing insurance to the insured are calculated. Hence,

$$\text{Premium} = \text{Cost of Insurance} + \text{Table Rating} + \text{Flat Rating} \quad (1)$$

The total fixed expenses incurred by the insurer for providing cover to a single insured are calculated as:

$$\text{Fixed Expenses} = \text{Administrative Expenses} + \text{Load Unit} \quad (2)$$

Where, Load unit is the initial amount for processing an insurance policy. The final amount which is collected from the insured as premium is termed as Actual Policy Value which is:

$$\text{Actual Policy Value} = \text{Premium} + \text{Interest} - \text{Fixed Expenses} \quad (3)$$

As discussed above, premium increases with the age of the insured. Hence, after every month, the Actual Policy Value is again calculated by deducting all the fixed expenses from premium and adding the accumulated

interest. For doing this, beginning of month of policy value is calculated on 1st of every month as follows:

$$APV1 = APV + \text{Pr}emium + Interest - Fixed\ Expenses \quad (4)$$

Where, APV i.e. Accumulated Policy Value is the last month's Actual Policy Value. There are various ways in which the interest on Actual Policy Value is calculated. In most of the cases, this interest adds daily. The exact procedure followed by an insurance company may differ from the above discussed steps, but the basic idea for premium calculation remains the same.

The introduction of a computer-based model that might aid the underwriter in the tedious process was a good initiative. An Artificial Neural Network can be trained to be used as an underwriter by insurance companies as a reliable and convenient tool. A well-trained network can be made proficient in handling routine applications allowing the human underwriters to spend more time on more complex policies. Thus the tool can be used to take decisions of whether to accept or reject the risk and how much insurance premium can be charged from the individual. This in itself is not a justification for using artificial neural networks, but it is enough motivation to try nontraditional techniques. While it is theoretically possible for an artificial neural network to handle the underwriting functions, a huge gap between the real-time portfolio handing and a computer portfolio handling is obvious to observe. At the same time the social feasibility of such a tool must also be considered.

The significance of a Neuro-fuzzy Network in current domain lies in the fact that a properly designed neural network with right choice of network architecture can accurately approximate any mathematical function. In the same direction, it may prove to better deal with the uncertainty and complexity of the relationship between input and output variables over other modeling methods. Although there exists a variety of tools for life insurance underwriting, it is certainly going to take time for insurance seekers and the insurance industry to understand and accept the Neuro-fuzzy underwriting models.

VI. EXPECTED RESULTS

Underwriters in insurance companies cannot efficiently utilize all the available information for taking the underwriting decisions. To overcome the problems with current human-based underwriting process, lot of automated underwriting models have been proposed by researchers, but none of them is capable of dealing with uncertainty persisting in the real world. With the benefit of the flexibility and adaptability of a fuzzy Neural Network, the insurance companies can enjoy more precise underwriting decisions. The proposed model is expected to have manifold advantages including, capacity to handle voluminous rules for decision making; expectation of less error rate over other traditional methods; possibility of adaptation to generalize on unseen cases; accuracy in determination of risk classes due to sufficient training to the neural network and lastly, tolerance in the inability of the individuals to provide accurate data due to fuzzy logic.

VII. FUTURE WORK

The model can be designed and implemented to assess the feasibility of applying Neuro-fuzzy network to perform the job of underwriter. The network can be trained to have dual functionality. First, a fuzzy neural network can be sufficiently trained to classify the individuals in one of the risk classes based on the inputs provided. Second, once the accept/reject decision is taken; an investigation can be done for setting the chargeable premium. Such model may prove to be proficient in reducing the insurance company's losses by generating precise results to overcome the human errors in calculation and decision making. This will not only shrink the cost of underwriting, but also help rationalize the business process and generate policies that are more correctly priced. If such model can be made available to the insurance seekers, it may develop awareness in them by drawing their attention to the degree of their health risk. The premium options may give them a better choice to opt for paying when they are availing the insurance.

VIII. CONCLUSION

Insurance is a sunrise sector today. The challenge for life insurance companies in the increasingly competitive market is to maintain profitability. Although it has started bending towards information technology for its improved results; the systems which are available in the market or on the Internet can only give reasonable outcomes when accurate and precise data is fed as input. The evolution of life insurance industry is in need of a reliable and robust risk assessment tool. Tools which deal with uncertainty can rarely be seen around for assessing the health risk and calculating insurance premium.

Underwriting is the base of all insurance industry. If the underwriters access the risk properly and rate the policy strictly in accordance to the underwriting principles and policies, the business can give great success, otherwise it may prove to be great risk for the insurance industry. The modern technique has made the insurance underwriting a quicker and more accurate process recently.

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Note: The methods involved in calculation of premium can vary from company to company and can change with time. Authors do not take the responsibility in case of alteration/modification/deletion/additions in calculating premiums on life-insurance policy covers. As insurance companies do not disclose the formula for calculating the insurance premium, a rough calculation is assumed to explain the possibility of applying proposed model in the insurance sector.