CHAPTER 9

Advanced Topics

INTRODUCTION

Mathematicians use some very complex formulas that involve even more complex variables and parameters to quantify and/or reproduce real life processes. We will not go there in this Guide.

What may be mentioned are the several reproducing or measuring systems commonly used by actuaries or risk-based mathematicians such as:

- Monte Carlo Simulations
- Stochastic Modeling
- Data Mining
- Predictive Modeling
- Robotics
- Futurism.

A few articles illustrative of these mathematical or risk management models from the North American Actuarial Journal are cited.

MONTE CARLO SIMULATION

The Monte Carlo simulation method is a technique that involves the use of random numbers and probability to solve problems; i.e., it evaluates repeatedly (as sampling) a deterministic model using sets of random numbers as inputs. This method is often used when the model is complex, nonlinear, or involves more than several uncertain parameters. A simulation can typically involve thousands of *evaluations* of the model, a task that in the past was only practical using super computers.

Monte Carlo simulation methods are based on the use of a stochastic technique in that they employ the use of random numbers and probability to investigate problems. One can find Monte Carlo simulation methods used in everything from economics to nuclear physics to regulating the flow of traffic. Of course, the way they are applied varies widely from field to field, and there are dozens of subsets of the Monte Carlo simulation method even within chemistry. But, strictly speaking, to call something a Monte Carlo simulation, all you need to do is use random numbers to examine some problem.

The use of Monte Carlo simulation methods to model physical problems allows us to examine more complex systems. Solving equations that describe the interactions between two atoms is fairly simple; solving the same equations for hundreds of thousands of atoms is impossible. With Monte Carlo simulation methods, a large system can be sampled in a number of random configurations, and that data can be used to describe the system as a whole.

Monte Carlo simulation methods are especially useful for modeling phenomena with significant uncertainty in inputs and in studying systems with a large number of coupled degrees of freedom.

STOCHASTIC MODELLING

Mathematical models can be categorized broadly as being probabilistic or deterministic. Among situations where probabilistic models are more suitable, very often a better representation is given by considering a collection or a family of random variables instead of a single one. Using collections of random variables indexed by a parameter such as time and space are known as stochastic modeling..lki

In applied statistics, after the collection of empirical data, a theoretical probability distribution is fitted in order to extract more information from the data. If the fit is good, the properties of the set of data can be approximated by the properties of the distribution. In a similar way, suppose that a real-life process has been observed to have the characteristics of a stochastic process. The knowledge of the behavior of the stochastic process in question is then highly desirable in understanding the real-life situation. This is especially true when the system to deal with is complex.

DATA MINING

In General

Data mining is the extracting of information inferencially from a database. The process converts the stored data into useful information. There are three uses of profiling practices that are discussed herein; (a) marketing surveillance, (b) fraud detection and (c) scientific discovery.

Data mining should not be used to (a) discover unrepresentative patterns, (b) *snoop* in a negative way or (c) *dredge*, (similar but not the same as snoop).

Generally, data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information – information that can be used to increase revenue, cuts costs, or both. Data mining software is one of a number of analytical tools for analyzing data. It allows users to

analyze data from many different dimensions or angles, categorize it, and summarize the relationships identified. Technically, data mining is the process of finding correlations or patterns among dozens of fields in large relational databases.

PREDICTIVE MODELING

Meanings

Predictive modeling means a process that is created to predict the probability of an outcome. In many cases, the model is chosen on the basis of detection theory to try to estimate the probability of a result given a set amount of input data; for example, given an email, determine how likely that it is spam. Data mining is also a process by which, given a number of predictors, or variable factors, how likely is it to influence future behavior or results. In marketing, for example, a customer's gender, age, and purchase history might predict the likelihood of a future sale.

The Model

In predictive modeling, (a) data is collected for the relevant predictors, (b) a statistical model is formulated and (c) predictions are made. The model Is then validated (or revised) as additional data becomes available. The model may employ a simple linear equation or a complex neural network, mapped out by a compute program. A very simple example of a predictive model is with a hospital ER that treats patients with a chest pain. Based on factors such as blood pressure, age, gender, severity of pain, location of pain, and other measurements, the caregiver must decide whether the pain indicates a heart attack or some less critical problem. A predictive model can be generated to decide which patients require immediate attention.

ROBOTICS

Potential

The use of intelligent machines (robots) to solve scientific, mathematical and engineering problems is commanding increasing interest. The ultimate goal is not merely to replace humans but to improve on their performance and capabilities. Consider the following:

- The robotics industry is huge (approximately $3B in revenue) and growing (some 20% per year).
- Robotics is playing a significant part in the science of medicine such as genetics, surgery and laboratory research.
- Important discoveries are being made in marine biology with underwater robots.

- Care-giving abilities of robots are being used with our increasing population of seriously handicapped people.
- Robots are assisting in the maintenance and upgrading of our infrastructure.

Special attention should be given to the increasing use of robotics jn business environments.

Mathematical Techniques

The mathematical techniques most often used in robotics are these:

- Algebraic and differential topology
- Dynamics systems theory
- Optimization of algorithms
- Combinatrics
- Differential algebraic inequalities
- Statistical learning theory.

FUTURISM

Meaning

Futurism is the study of what might occur in the future and preparing appropriate responses. Futurists admit that the future of human systems is inherently uncertain. Rather than assume that such uncertainty doesn't exist, they deal with it head-on. Futurists forecast in the form of scenarios rather than predictions and they contemplate and attempt to measure the uncertainty of the future.

Process

The actuary typically will rely on either (or both) of these two tools: the Delphi Method or the Predictive Marketing Method.

Delphi Method

The Delphi method is a systematic, interactive forecasting method which relies on a panel of independent experts. The carefully selected experts answer questionnaires in two or more rounds. After each round, a facilitator provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers will decrease and the group will converge towards the *correct* answer. Finally, the process is stopped after a pre-defined stop criterion (e.g. number of rounds, achievement of consensus, stability of results) and the mean or median scores of the final rounds determine the results.

Predictive Marketing Method

The Predictive Marketing Method operates under different names; (a) information markets. (b) decision markets, (c) ideas futures, (d) event derivatives or (e) virtual markets.

The simple idea of predictive marketing is to (a) ideate a menu of social, economic, political, population events that might occur in the future and then (b) compute the economic impact of such events.

Neural Networks

An artificial neural network is an emulation of a biological neural system. Although current computing systems are truly advanced, there are certain tasks that a program made for a common microprocessor is unable to perform. Even so, the software implementation of a neural network can be made with advantages and disadvantages.

Advantages:

- A neural network can perform tasks that a linear program can not.
- When an element of the neural network fails, it can continue without any problem by their parallel nature.
- A neural network learns and does not need to be reprogrammed.
- A neural network can be implemented in any application.
- IA Neural network can be implemented without any problems.

Disadvantages:

- The neural network needs training to operate.
- The architecture of a neural network is different from the architecture of microprocessors.
- The neural network requires large computer processing time for large neural networks.

NORTH AMERICAN ACTUARIAL JOURNAL

In General

This publication is the premier publication of the Society of Actuaries. The readership extends beyond the actuarial community and includes international scientific, academic, business and governmental communities.

The Journal purposes to stimulate research on emerging public policy issues, technological improvements, demographic trends, multidisciplinary topics, etc.

The articles typically are quite erudite and replete with mathematical symbols unfamiliar to most persons. Even so, the articles have value because of their (a) currency (b) insight and (c) readable abstracts.

Summary of Selected Papers

Papers of interest which have relevance to the topics of this text are summarized in the following paragraphs.

Ruin Models [1]

A number of articles have been published that deal with ruin models. Suppose we (a) quantify the fixed contributions (escalated by trending), (b) project claims (presumed to be distributed lognormal) (c) establish a census of covered persons (assumed to be dynamic and (d) assume an interest rate on behalf of a single employer self-funded health care plan. The ruin model would provide, for any set family of assumptions these three products (a) the time to ruin, (b) the surplus prior to ruin and (c) the defect at ruin.

Claim Reserves [2]

A number of articles apply traditional Bayesian algebra, typically referred to as the chain-ladder method. Some of the problems often dealt with in these articles include (a) outliers and (b) predictive errors.

Managed Care and Performance Measures [3]

The practice of using performance measures (or report cards) to assess the quality of care provided by managed care organizations is well known. These are significant gaps in our understanding, however. Examples include: (a) the impact that formal plan evaluations have on contracting and enrollment decisions by both the providers and the consumers. The absence of this information may be quite hurtful to the managed care effectiveness.

Evaluating Managed Effectiveness [4]

The importance of managed care networking to our health care system cannot be overemphasized. This article deals with the functional components of managed care; it deals also with the market forces underlying the health care system and their effect thereon. The analysis concentrates on the societal goals for health care and attempts to

measure the impact of managed care on such effectiveness. The analysis summarizes the interactions between the many parties to the providing and financing of health care.

Predictive Modeling – Chronic Disease Costs [5]

Approximately 75% of our nation's health care expenditures are for chronic diseases; also, many of our chronic diseases are punctuated by periods, of acute illness which serve to *spike* the costs. What is desired is a predictive model that will give some reasonable estimate of (a) future costs and (b) cost variability. A model was created using Bayesian statistics that predicted the incidence and cost of a period of hospitalization for a particular chronic disease. This technique when full developed would be most helpful in the pricing and funding of self-funded health care plans.

Endnotes

1. See 5 NAAJ2 (2001); 11 NAAJ3 (2007) 11 NAAJ3 (2007) 12 NAAAJ 1, 3 (2008); 13 NAAJ1, 2 (2009)
2. 12 NAAAJ 2 (2008); 13 NAAJ 2 (2009)
3. 4 NAAJ 2 (2001)
4. 5 NAAJ 4 (2001)
5. 12 NAAJ 1 (2008)