# *REVIEW OF LITERATURE*

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In 1965, ZADEH published a paper entitled "Fuzzy Sets" in a little known journal, Information and Control, introducing for the first time sets of objects whose boundaries are not sharply defined. This paper gave rise to an enormous interest among researchers, and initiated the fulgurant growth of a new discipline of mathematics, fuzzy set theory. To quote ZADEH, "as the complexity of a system increases, our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance become almost exclusive characteristics" Computers cannot adequately handle such problems, because machine intelligence still employs sequential (Boolean) logic.

The number of papers related to the field exploded from 240 in 1975 (ZADEH et al.) [58], to 760 in 1977 (GUPTA et al.) [30], 2500 in 1980(CHEN et al) [15], and 5000 in 1987 (ZIMMERMANN) [65]. Today, there are many more researchers in fuzzy set theory than in actuarial science, and they form a much more international group, with important contributions from China, Japan, and the Soviet Union. Two monthly scientific Journals publish new theoretical developments and applications, that are to be found in linguistics, risk analysis, artificial intelligence (approximate reasoning, expert systems), pattern analysis and classification (pattern recognition, clustering, image processing, computer vision), reformation processing, and decision- making.

Basically, Fuzzy Logic (FL) is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like

way of thinking in the programming of computers. Fuzzy systems are an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy. The precision of mathematics owes its success in large part to the efforts of Aristotle and the philosophers who preceded him. In their efforts to devise a concise theory of logic, and later mathematics, the so-called "Laws of Thought" were posited [32]. One of these, the "Law of the Excluded Middle," states that every proposition must either be True or False. Even when Parminedes proposed the first version of this law (around 400 B.C.) there were strong and immediate objections: for example, Heraclitus proposed that things could be simultaneously true and not true. It was Plato who laid the foundation for what would become fuzzy logic, indicating that there was a third region (beyond True and False) where these opposites "tumbled about". Other, more modern philosophers echoed his sentiments, notably Hegel, Marx, and Engels. But it was Lukasiewicz who first proposed a systematic alternative to the bi–valued logic of Aristotle [37]. Even in the present time some Greeks are still outstanding examples for fussiness and fuzziness, (note: the connection to logic got lost somewhere during the last 2 mileniums [39]). Fuzzy Logic has emerged as a profitable tool for the controlling and steering of systems and complex industrial processes, as well as for Household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data.

A clear distinction has to be made between fuzzy set theory and probability theory even though they both deal with uncertainty. Probability concepts are derived from considerations about the uncertainty of propositions about the real world Fuzzy concepts are closely related to the multivalued logic treatments of issues of imprecision in the definition of entities Hence, fuzzy set theory provides a better framework than probability theory for modeling problems that have some

inherent imprecision. Lemaire's 1990 paper [40] presents some of the first applications of fuzzy Set theory in actuarial science.

The insurance industry has numerous areas with potential applications for fuzzy logic (FL). These include classification, underwriting, projected liabilities, fuzzy future and present values, pricing, asset allocations and cash flows, and investment. Given this potential and the impetus on FL during the last decade, it is not surprising that a number of FL studies have focused on insurance applications. The specific purposes of the article are two-fold: first, to review FL applications in insurance so as to document the unique characteristics of insurance as an application area; and second, to document the extent to which FL technologies have been employed.

In their paper "An overview of an insurance using fuzzy logic" ,"Fuzzy insurance", "The Application of Fuzzy sets to Group Health Underwriting" they explored some possible applications of fuzzy set theory to Insurance. It has been twenty-five years since Dewit (1982) [21] first applied fuzzy logic (FL) to insurance. The article sought to quantify the fuzziness in underwriting. Since then, the universe of discourse has expanded considerably and now also includes FL applications involving classification, projected liabilities, future and present values, pricing, asset allocations and cash rows, and investments. The article "An overview of an insurance using fuzzy logic" presents an overview of these studies. The two specific purposes of the article are to document the FL technologies have been employed in insurance-related areas and to review the FL applications so as to document the unique characteristics of insurance as an application area.

Lemaire [40] provides a model for underwriting individual life insurance using fuzzy sets. We follow Lemaire's lead by creating models for

underwriting group health insurance. They examined single- option plans, and multiple-option plans. The Society of Actuaries has published several Study Notes that contain rules for group selection [39, pp. 2, 10-18], [44, pp. 48-52], and [50. Pp. 4-9]. One problem is to determine how these underwriting rules interact.

Fuhrer and Shapiro [28] model selection in multiple-option plans, and Mailander [41] lists factors that influence selection in such plans. These include the plan of benefits, access to care, employee costs, and the age, sex, and marital status of the individuals in the group. Also, the applications of fuzzy sets cover a broad range, such as artificial intelligence, linguistics, economics, decision-making, and consumer products.