CHAPTER 1
INTRODUCTION AND PROBLEM STATEMENT

1.1. INTRODUCTION
Student academic performance evaluation involves several components, each based on number of imprecise judgments arising due to human (teacher/tutor) interpretation. Both arithmetical and statistical methods have been used for aggregating information from these assessment components in educational domain. These commonly used methods have some limitations. For example, in a scenario two student’s scores are 50, 60, 70, and 70, 60, 50 in three tests, respectively. The average mark obtained by each is 60 without any indication of their intelligence level. However, data indicates that one student is improving while other is deteriorating consistently (i.e. one student is learning consistently). Recently, methods have been developed for the application of fuzzy set theory in student performance evaluation and concept maps construction which provides adaptive learning guidance to students. Learning achievement evaluation needs solution of subjective judging problem, difficulty and complexity of questions faced by the teachers [1]. Concept maps construction for adaptive learning guidance to students require consideration of achievement similarity between concepts [2].
The main aim of educational institutions is to provide student with the evaluation reports regarding their test/examination as best as possible with minimum errors. Some factors other than academic have been reported to creates/poses barrier to students attaining and maintaining their high performance [3]. Grouping or clustering of students using cognitive as well as affective factors and then defining the performance measure may be a realistic approach. Fuzzy evaluation method (FEM) for applying fuzzy sets in students’ answerscript evaluation [4] may serve the purpose. The fuzzy marks awarded to student’s answerscripts can be represented by fuzzy sets. In a fuzzy set, the grade of membership of an element \( u_i \) in the universe of discourse \( U \) belonging to a fuzzy set is represented by a real value between zero and one. The present study argued that the arithmetical and statistical techniques for classification and grading student academic performance
have several limitations and are least appropriate to evaluate knowledge and skills. The present thesis includes the role of fuzzy logic, fuzzy system, various characteristics of fuzzy logic system, linguistic variables, rules and membership functions and the implementation of performance analysis methodology with the help of fuzzy logic system. Reasoning based on fuzzy models and fuzzy clustering methods may yield alternative methods having potential to handle various kinds of imprecise data and improve the degree of judgments.

Some works related to academic performance evaluation based on Fuzzy sets and other soft computing techniques have been developed. Methods based on fuzzy sets and fuzzy rule base to assign grades to students and calculate the students’ academic performance are available [5-6]. Non-classical performance evaluation methods (such as fuzzy logic, a mathematical technique of set-theory) can also be applied to many forms of decision-making including research on engineering and artificial intelligence [7]. A fuzzy system, a mathematical model, that analyzes input values in terms of logical values in addition to numerical values. In fuzzy logic applications non-numeric linguistic variables are often used to facilitate the expression of rules and facts. The performance appraisal system can be examined using Fuzzy Logic Approach [8] as in the present study. Cascaded fuzzy inference system based on specific performance appraisal has been used to generate the performance qualities of some non-teaching staff of Universities [9-10]. A novel fuzzy qualitative classification system for academic performance evaluation using the link analysis methodology has been developed. Unlike the conventional approach, fuzzy rules based model involve variables, classes and their relations as elements of social network that can be modeled as a weighted graph [11]. Hameed has presented a more reliable system of student evaluation based on Gaussian membership functions [12] where three fuzzy nodes system (each nodes applies fuzzification, fuzzy inference, and defuzzification) has been considered (i.e. difficulty, importance and complexity of questions). Expert system technology using Fuzzy Logic is very interesting for qualitative facts evaluation; model of fuzzy expert system based on various key performance attributes is available to evaluate teacher’s performance [13]. Also the fuzzy method has been applied in evaluation of student’s oral presentation which involves application of membership function graph to identify the membership value of each satisfaction
level [14-15]. Fuzzy logic based engineering student’s evaluation for practical [16-17]. Such student’s performance in three sub-components showed difference in outcome compared to classical approach. The fuzzy based approach to circumvent the performance evaluation of the student based purely upon the numeric grading without entailing the human judgmental component [18]. Evaluations of Government officer’s performance with the help of various parameters have been carried out by applying fuzzy inference system (FIS) [19]. This help in formulation of mapping from a given input. The fuzzy logic systems enable one to validly predict distance student’s performance according to the expert opinion [20-21]. FIS for student academic performance evaluation is based on Fuzzy Logic Techniques where performance depends on exam results and it is evaluated as success or failure [22]. Methods to measure the performance of the students in junior high school [23], performance of teachers [24], and determination of grades to the students [25] are available. System considering the difficulty, the importance and the complexity of each question before determining a final grade [26] has also been worked out. Considerable attention has been given to adopt fuzzy approaches for evaluation of teaching performance by using computer particularly in Intelligent Tutoring Systems (ITS) and Computer Assisted Instruction (CAI) [27-28]. Fuzzy approaches have been proposed for determination of student’s understanding level of certain subjects in context of ITS, and student performance based on several criteria with a strong suggestion that the method be applied to CAI. Currently, much attention has been given to such aspects globally. This includes evaluation of journal grades, evaluation of vocational education performance, collaborative assessment, and performance appraisal system of academic in higher education. Data Mining (DM) or Knowledge Discovery in Databases (KDD) is an approach for shorting useful information from large data [29]. DM applies various methods in order to discover and extract patterns from stored data, and is widely used in educational field to find out hidden patterns. Educational data mining is focus of research for studying the behavior of students based upon their past performance [30-33]. Fuzzy Probabilistic Neural Network model, enabling design of an easy-to-use, personalized student performance prediction component [34]. Techniques for capturing the teacher’s knowledge for monitoring learners’ activities in Neuro-
fuzzy model for online automatic monitoring have been worked out [35]. The model intelligently provides inbuilt competence assessment and promptly takes decisions. A neuro-fuzzy approach for classifying students based on previous exam results and other related factors show potential for labeling students to anticipated academic performance [36]. Bayesian network classifiers predict the student's academic performance and generate model which helps in identifying the drop outs students needing special attention from teacher for appropriate counseling/Advising [37]. The Neural Network model is able to provide an adequate model for predicting performance evaluation effectively [38]. The simulation of Artificial Neural Networks (ANNs) has been used for evaluation of academic achievement in learning children as an adopted mathematical topic namely long division problem [39]. In neural network (or parallel distributed processing) neurons act similar to models of biological neurons and as conceptual components for circuits that could perform computational works. ANN has a large number of highly interconnected processing elements (nodes or units) that usually operate in parallel and are configured in regular architectures. The collective behavior of an ANN, like a human brain, demonstrates the ability to learn, recall, and generalize from training patterns or data. An Artificial Neural Network (ANN) model reported along with computation also derives meaning from imprecise data, extracts patterns and detects trends [40-41]. This advancement adds new dimensions in working out the complex phenomena that is buried in students’ data remained unnoticed by hard computing techniques. The adaptive Neuro-fuzzy inference system (ANFIS) is one of the examples of Neuro-fuzzy systems in which a fuzzy system is implemented in the framework of adaptive networks [42]. ANFIS constructs an input-output mapping both based on human knowledge (as fuzzy if-then rules) and generated input-output data pairs by using a hybrid algorithm i.e. combination of the gradient descent and least squares estimates.

Soft computing is an approximate solution to a precisely formulated problem (or more typically), or an imprecisely formulated problem [43]. The use of soft computing approaches for academic performance evaluation is fairly new approach to solve problems such as decision making, modeling and control problems. In addition to evaluation of student academic performance, wide
applications of soft computing include the evaluation of educator curriculum (e.g. lecturers and tutors). In student performance evaluation fuzzy techniques based on numerical scores obtained in an assessment have been adopted for assessing prior achievement based on academic certificates. Emerging soft computing approach parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision [44]. It consists of many complementary tools such as artificial neural network (ANN), fuzzy logic (FL), adaptive Neuro-fuzzy inference system (ANFIS) and regression analysis. Artificial neural network (ANN) model is a system of interconnected computational neurons arranged in an organized fashion to carry out an extensive computing to perform mathematical mapping [45]. An in-depth consideration of available approaches (fuzzy logic, neural network and fuzzy neural network) indicates that membership function and fuzzy rules have been defined by the experts which may lead to errors and make them less suitable for evaluation of students performance. Generally overlooked, automatic generation of fuzzy membership function and rules are promising and need a fresh insight. The proposed Subtractive Clustering Adaptive Neuro Fuzzy Inference System (SC-ANFIS) automatically converts the crisp data into fuzzy set and also calculates the total mark of a student appeared in semester-1, semester-2 and semester-3 examinations. The proposed idea is a starting attempt to use the applicability of Subtractive clustering technique and Adaptive Neuro Fuzzy Inference System (ANFIS) to analyze and find out modeling academic performance and to improve the quality of the students and teachers performance in teaching/learning strategies. The Subtractive Clustering technique, data warehousing and data mining techniques is more effective to improve the quality of education and instruction design.

1.2. PROBLEM IDENTIFICATION

This section gives an overview of student academic performance evaluation and identifies the problem to be tackled. Also describes are the research objectives of present work.
1.2.1. Overview of Students Academic Performance

Evaluation of student performances is one of the most important aspects in Indian educational systems. It has to be done for several important reasons arranged below. It aims to provide scoring or grading scheme that is interpretable by ordinary people, especially students, teachers, parents, employers and policy planners.

1.2.1.1. Reasons for Students Academic Performance Evaluation

There are several important reasons why student performance needs to be assessed. Firstly, the evaluated level of performance can be used as an indicator of student understands. This is important in providing information for teachers to take further action if necessary, such as planning remedial activities, or planning further instruction. This information also enables students to overcome weaknesses. Besides this, students who succeed in examinations may be motivated to learn more [46]. Secondly, assessment is important for the purpose of making academic decisions about the students now, or in the future. For example, students not achieving a certain level have to repeat the course while other students will proceed onto the next stage. Assessment is also important to indicate the level of performance for gradation purpose usually has a permanent effect on the future career of students [47]. Thirdly, assessment is important to provide information about the teacher’s ability to instruct and the ‘system’ being practiced. The reasons for assessing students [48] may be summarize as follows:

1. To provide feedback on the effectiveness of teaching staff.
2. To determine the course aims achieved.
3. To find out effectiveness of learning environment.
4. To decide standard over time, if required.

1.2.1.2. Format of Academic Performance Evaluation

Evaluation of academic performance can be done in the format of formative assessment or summative assessment. Formative assessment is conducted to monitor the progress of instruction. This is important to give feedback to students and teachers [49]. This type of assessment usually involves a wide range of
activities on frequent occasions, such as a series of observations, short tests and quizzes etc. Summative assessment is conducted at the end of each instructional segment through tests and final examinations to provide information on how much the students have archived [48]. The final evaluation involves combination of summative assessment and formative assessment. There are several possible reasons for using this combination, for example:

1. Uses of different types of assessment have different aims to measure students’ achievement. There is a wide range of assessment that can be chosen, such as classroom observations, essays, homework, open book tests, portfolios, etc. Few methods may be more suitable to assess what cannot be assessed in final written examinations, such as investigation and group work. Written examinations at the end of the course may not provide a complete picture of students [50].

2. Assessment is a part of learning process and should not be done after teaching is over [51]. Continuous assessment in the form of formative assessment will provide feedback in regards to student performance at an early stage of the course. Discussion of student’s errors in a series of tests or quizzes will reinforce their knowledge acquisition.

3. Combination of various assessment methods are generally viewed as essential to provide full coverage of important learning outcomes [52-53]. Multiple assessments determine clearly measure for educational experience.

4. To motivate students; e.g. higher marks obtained in continuous assessment may motivate students to work harder for a final examination.

Various modes of evaluation methods have been used for primary, secondary and higher education. Wide spectrum of evaluation methods also exist in different countries. For example, in 1996 there have been at least 137 different strategies of evaluation [54] in Scottish Higher Education reflecting their wide amplitude.

1.2.1.3. Assessment Components

Academic performance evaluation usually consists of several assessment components. These components consist of a wide variety of assessment methods such as Series of tests and quizzes, Portfolios, Formal written examinations, Individual Assignment and Coursework, Group work, Observations, Thesis and
Publishable materials, Posters and Oral presentations. Different assessment components reflect different modes of evaluation used to assess student academic performance.

1.2.1.4. Existing Methods to Represent Academic Performance

Student academic performance evaluation usually involves awarding numerical values or linguistic labels to a given piece of student work. These values and labels have been used to represent student achievement by reasoning with arithmetical or statistical methods. A combination of various assessment components has been used for different allocation patterns of marks. By using arithmetical methods, for example different scores from each assessment are added up to obtain a single score. Simple statistical methods such as calculating the average from several assessments are also often used. Further, analysis of students’ scores can be made using more complex statistical methods such as calculating the mean, median, mode, range, standard deviation, skewness, variance and standard “Z-score”. In general, methods represent student’s academic performance can be classified into several categories:

1. Single letter-grade (e.g. A, B, C, D, E, F). These letter-grads are usually based on a numerical interval-value that refers to a certain category of achievement.
2. Normal score (e.g. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10) refer to another numerical interval-value that refers to certain category of achievement.
3. Single numerical score that usually refers to 100.
4. Linguistic terms such as “Pass” and “Fail”.
5. Single ‘fine’ grade-points from 0.00 to 4.00 (400 points: 0.00, 0.01, 0.02,….3.99, 4.00) based on Grade-Point Average (GPA) and Cumulative Grade-Point Average (CGPA).

Combination of different methods has been also used i.e. the use of GPA alongside the single letter-grade. Numerical scores have been predominantly used than letter-grade or linguistic terms because grades using numbers can be used for further arithmetical or statistical analysis.
1.2.2. Research Problem
Student accessing the quiz and test in educational domain are normal activities to evaluate the student performance. Normally, score is used as a factor for indentifying the student performance. However, it is a challenge when more factors involve in determine the student performance, such as semester-1, semester-2, semester-3, sessional marks, attendance etc. The reasoning of the student’s performance for multiple factors is very difficult. Very often this results in misleading evaluation of students on short time basis. Common use of Grade Point Average (GPA) as is computed from student’s aggregated numeric grade using statistical measures. The aggregation does not reflect student’s Continuous Performance Assessments (CPA). Also, the statistical measures (like average) may lead to wrong conclusion. Soft computing techniques used for student’s performance evaluation in the present work aims to strengthen the present system by providing additional information for decision making by the users.

1.3. RESEARCH OBJECTIVE(S)
The present work has been carried out with following objectives:
1. To find out applications of soft computing techniques based on previous or current data for classifying student academic performance. Further develop fuzzy rule model which will allow inference to be obtained in a more natural way using linguistic variables rather than numerical values.
2. To develop Fuzzy rule model using soft computing techniques such as Fuzzy Clustering and Neuro Fuzzy Systems (e.g. FCM, SC, hybrid SC-FCM and hybrid SC-AIFIS).
3. To investigate the effectiveness of such models in handling multiple attributes, containing imprecise data.
4. To determine most suitable model (from the ones obtained from “2” above) by comparing the models.

1.4. SCOPE OF STUDY
This study aims to develop a fuzzy systems and other related soft computing techniques like fuzzy clustering and Neuro Fuzzy Systems for academic
performance evaluation. It aims to builds a method which used soft computing models and their associated inference mechanism for student academic performance evaluation.

1.5. FOCUS OF STUDY
For the purpose of the research, traditional methods of student performance evaluation (referred hereafter as non-fuzzy approaches) mainly the methods that use statistical techniques. Due to diversity of existing educational evaluation methods, this research will focus on “high level” of student’s academic performance. The proposed methods will be applied hierarchically for aggregating scores from student examination data to produce a score for individual modules, aggregating results of different modules to produce a score for yearly performance and aggregating different years’ achievement to produce an overall performance.

1.6. CONTRIBUTION
The methodology (soft computing techniques, described in detail in chapter 3) for the present research framework involves phases named as; problem analysis, designing, implementation and testing, result analysis and discussion. These phases help in achievement of the objectives of this study:

1. **To study and analysis on the Fuzzy Inference System:** In preliminary result phase, the construction of human expert Fuzzy Inference System (FIS) and Bayesian technique has been design to solve the problem of reasoning of the student’s performance based on the 25 fuzzy rules and allocation of new student admitted.

2. **To analyze the student’s performance based on the fuzzy logic, fuzzy clustering and Neuro-Fuzzy system techniques:** In experimental result and analysis phase, the construction of human expert fuzzy inference system and Neuro-Fuzzy has been able to train based on the 8 fuzzy rules generate complete fuzzy rule based system.

3. **To develop student performance model based on Fuzzy clustering and Neuro-Fuzzy system techniques and test the proposed research:** Several testing and experiments have been varied out to classify the students’
performance into five categories, i.e. unsatisfactory, satisfactory, average, good and excellent. Finally, the comparison of the classification results based on the human experts fuzzy rule base, fuzzy clustering and Neuro-Fuzzy Inference system.

In this study, fuzzy inference models provide an efficient way to reason about a student’s performance in quantitative way. However, the number of fuzzy rules acquired from human experts has always been incomplete and inconsistent. This study describes fuzzy clustering and combines techniques of fuzzy logic and neural network approach with a sufficient training datasets in determining the fuzzy rules from a fuzzy rule base system of the student model. The Fuzzy clustering and Neuro-Fuzzy system approach have successfully solved the problem of incompleteness in the decision made by human experts. A complete fuzzy rule base is formed by generating all possible fuzzy rules from the given fuzzy variables and term sets. By training the Neuro-Fuzzy system with selected patterns that are certain, the proposed approaches were expected to produce decisions that could not previously be determined. Although the Fuzzy clustering and Neuro-Fuzzy system approach have successfully given the desired results for any possible given input, this rule base is found to be inconsistent in that some of their rules have illogical conditions. Therefore, the increments of the training datasets and several experiments have been conducted to assess the modeled ANFIS and finally it has produced an acceptable classification results.

REFERENCES


