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Innovative Approaches in Student Performance Evaluation through Neuro-Fuzzy Intelligent Systems

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Abstract: ***In this research paper, an intelligent system based on neuro-fuzzy techniques[1] is developed for the evaluation of students performance. The system comprises five inputs and one output. The inputs include engagement survey results, students satisfaction levels, special project cost, days present in the last 30 days, and absence records. The output is the performance score[5] of a students. Membership functions are defined for each input and output, with three membership functions for each input and four for the output. The proposed work section details specific membership functions, and MATLAB is utilized for the implementation of the entire project. Data for the research is sourced from Kaggle data[4], and the accuracy of the proposed technology is reported to be 95%.***

Keywords: neuro-fuzzy techniques, student performance evaluation, MATLAB implementation, Kaggle data, performance score

1. Introduction

Fuzzy logic serves as a technique for constructing models that leverage real data within a structured range, aiming to retain key aspects of classical reasoning. It proves particularly valuable when dealing with imprecise information and making informed decisions in uncertain environments. The construction of a fuzzy expert system involves three stages. The initial stage involves transforming the non-fuzzy set into the fuzziest form, a process known as fuzzification. Subsequently, in the second stage, the input fuzzy set is transformed into the output fuzzy set.

The third step in the process involves converting the fuzzy set value into a tangible or concrete value. The Mamdani fuzzy system, renowned for encapsulating expert knowledge, employs a method that effectively presents information in a more discernible manner. Specifically, the Mamdani fuzzy system utilizes the defuzzification method to transform a fuzzy result into a clear and understandable outcome.

The Mamdani fuzzy system finds common application in decision support contexts, leveraging its perceptive rule base. During the system design phase, the Mamdani fuzzy system exhibits rigidity. In contrast, the Sugeno fuzzy system calculates its crisp output through the weighted average method, eliminating the need for a defuzzification process. Consequently, in the Sugeno fuzzy system, the defuzzification phase is omitted.

Notably, the Sugeno fuzzy system lacks output membership functions. Its computational capability, coupled with compatibility with adaptive and optimization procedures, renders the Sugeno approach particularly effective in addressing direct issues.

Optimization and adaptive techniques have the capacity to modify membership functions, ensuring the fuzzy expert system structures data optimally. The neuro-fuzzy techniques[1], employing an adaptive approach, merges fuzzy logic with neural networks, creating a hybrid technology that holds the promise of enhanced efficiency. Consequently, the adaptive neuro-fuzzy expert system presents a dynamic solution methodology.

2. Problem Definition

A student performance evaluation[2] involves assessing an individual's class performance and responsibilities. The purpose of performance evaluations is ideally to provide a platform for both the students and teacher to identify and discuss areas for improvement. Additionally, it serves as an opportunity to reaffirm or clarify expectations between the student and teacher. Mismanagement of performance management can adversely impact a corporation in various ways.

When students excels in their performance but perceives unfair treatment, it can result in a decline in self-esteem, fostering resentment towards university/college, reduced engagement, and diminished performance in study. Providing negative feedback without substantiating it with data or facts poses potential risks. Students who feel unjustly evaluated may take legal action against the teachers. Moreover, Teachers are prone to delivering biased reviews when lacking data and metrics as a foundation for their evaluations.

Consequently, there is a need for intelligent systems to tackle these challenges. Basic rule-based intelligent systems lack the capability to assess the probability of an accurate students performance rating. In such simplistic rule-based systems, a single missing parameter can lead to an inaccurate evaluation of the students. The fundamental approach in intelligent systems involves prompting the user with questions regarding the values of evaluation parameters, to which the user responds with yes or no. If all evaluation parameters receive affirmative responses, the evaluation proceeds using the straightforward rules of the system.

Hence, basic rule-based intelligent systems lack the capability to estimate the likelihood of evaluations. Consequently, there arises a need for the incorporation of fuzzy logic. Fuzzy logic enables the system to calculate the probability that the evaluation aligns closely with reality. However, a drawback of fuzzy intelligent systems is the manual selection and design requirement for membership functions and fuzzy rules, posing a significant challenge in fuzzy modeling. To overcome this limitation, the study employs a hybrid model—specifically, a neural fuzzy inference system—for Students performance evaluation. Notably, the rules and membership functions in this inference system are generated automatically.

3. Proposed Work

The proposed intelligent system, employing the neuro-fuzzy techniques[1], incorporates five inputs. These inputs include:
1) Engagement Survey
2) Student Satisfaction
3) Special Assignment Count
4) Days Late in the Last 30
5) Not Present in class

1) Engagement Survey

The "Engagement Survey" input is characterized by three distinct membership functions: Contented, Satisfied, and Unsatisfied. Figure 1 illustrates these membership functions.

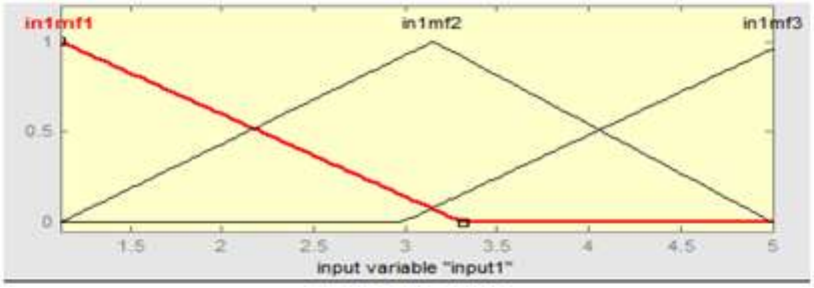

Figure 1: Membership Functions for the Engagement Survey

In1mf1: input1, membership function 1
In1mf2: input1, membership function 2
In1mf3: input1, membership function 3

2) Student Satisfaction

Similarly, the "Student Satisfaction" input comprises three membership functions: Good, Average, and Poor. These functions are visually represented in Figure 2.

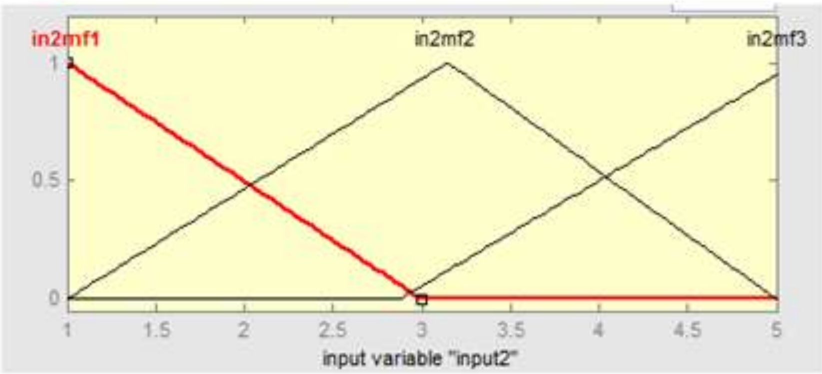

Figure 2: Student Satisfaction

In2mf1: input2, membership function 1
In2mf2: input2, membership function 2
In2mf3: input2, membership function 3

3) Special Assignment Count

The "Special Assignment Count" input also includes three membership functions: Poor, Normal, and Outstanding. These functions are depicted in Figure 3.

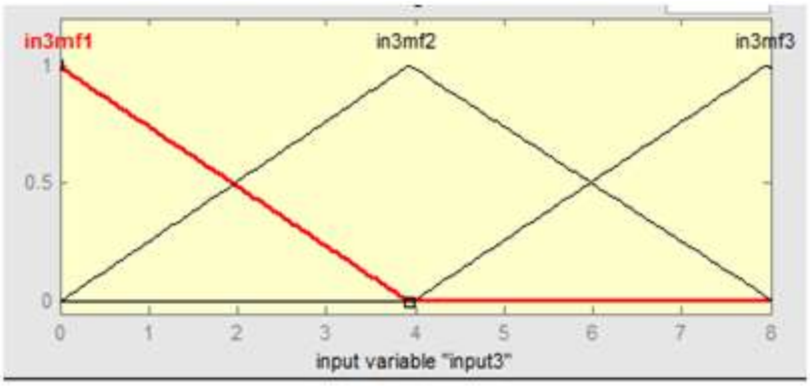

Figure 3: Membership Functions for Special Assignment Count

In3mf1: input3, membership function 1
In3mf2: input3, membership function 2
In3mf3: input3, membership function 3

4) Days Late in the Last 30

Similarly, the "Days Late in the Last 30" input consists of three membership functions: High, Moderate, and Low. These functions are visually represented in Figure 4.

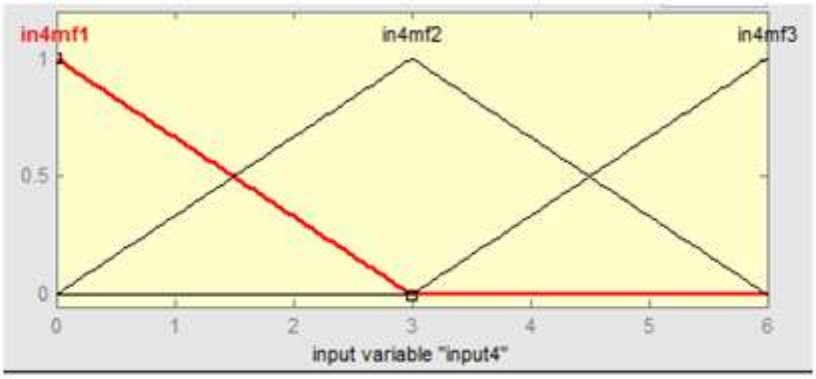

Figure 4: Membership Functions for Days Late in the Last 30

In4mf1: input 4, membership function1
In4mf2: input 4, membership function2
In4mf3: input 4, membership function3

5) Not Present in class

The "Not Present in class" input is characterized by three membership functions: High, Average, and Low. Figure 5 visually illustrates these membership functions.

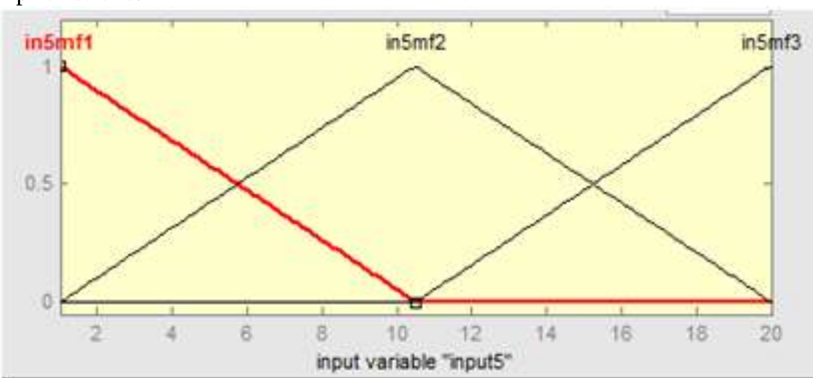

Figure 5: Input membership functions for Not Present in class

In5mf1: input 5, membership function1 In5mf2: input 5, membership function2 In5mf3: input 5, membership function3

The outcome of the suggested system is the performance score[5], and its associated membership functions are:
a) Needs Improvement b) Performance Improvement Plan c) Fully Meets d) Exceeds

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The configuration of the system, along with the rules, rule viewer, surface viewer, ANFIS (Adaptive Neuro-Fuzzy Inference System) structure, and training error, is depicted in Figures 6, 7, 8, and 9, respectively.

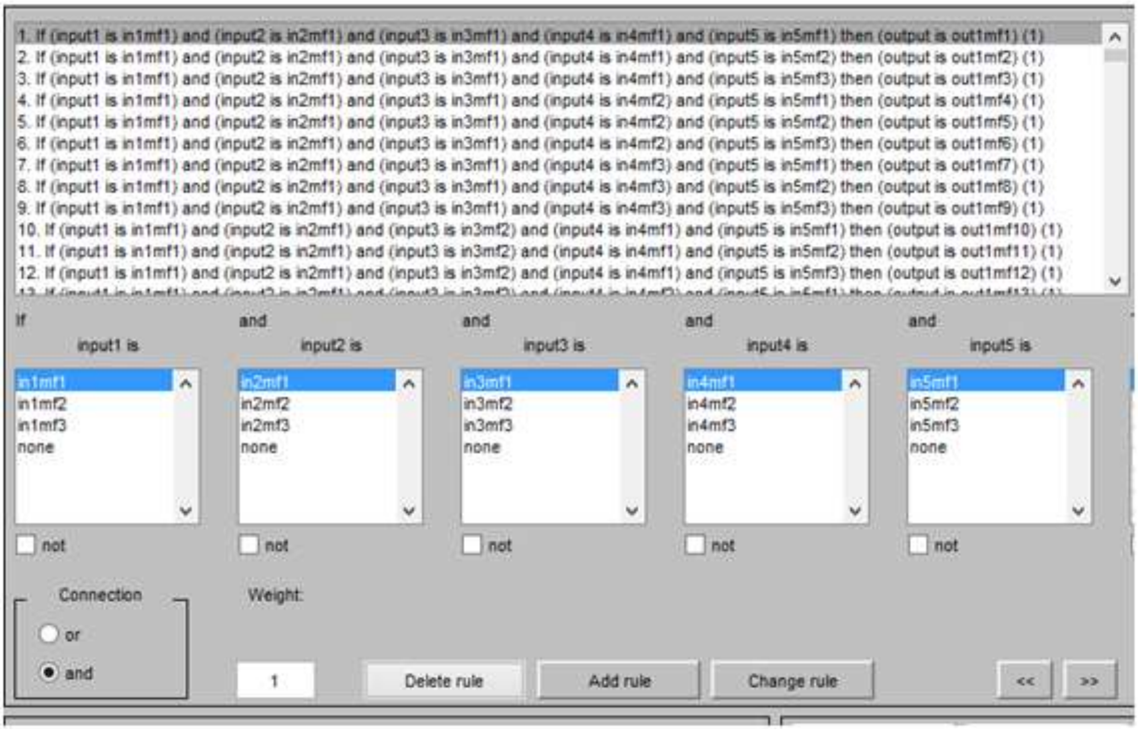

Figure 6: Rules

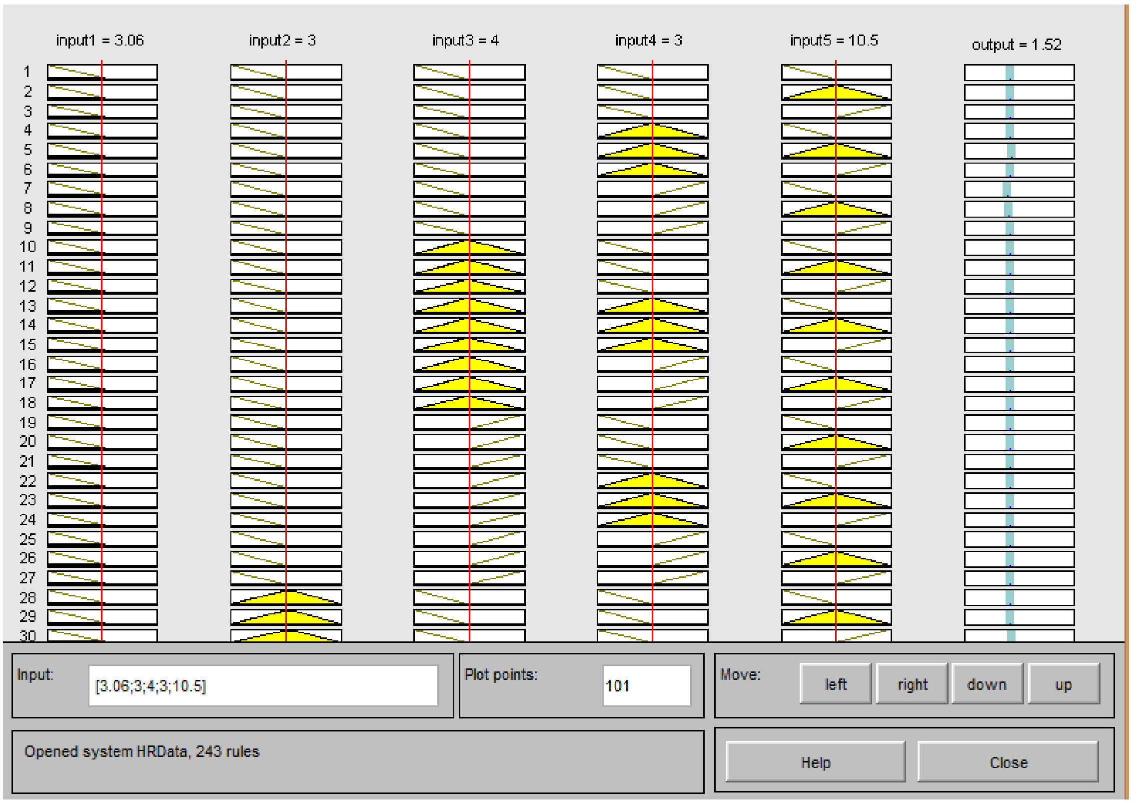

Figure 7: Rule Viewer

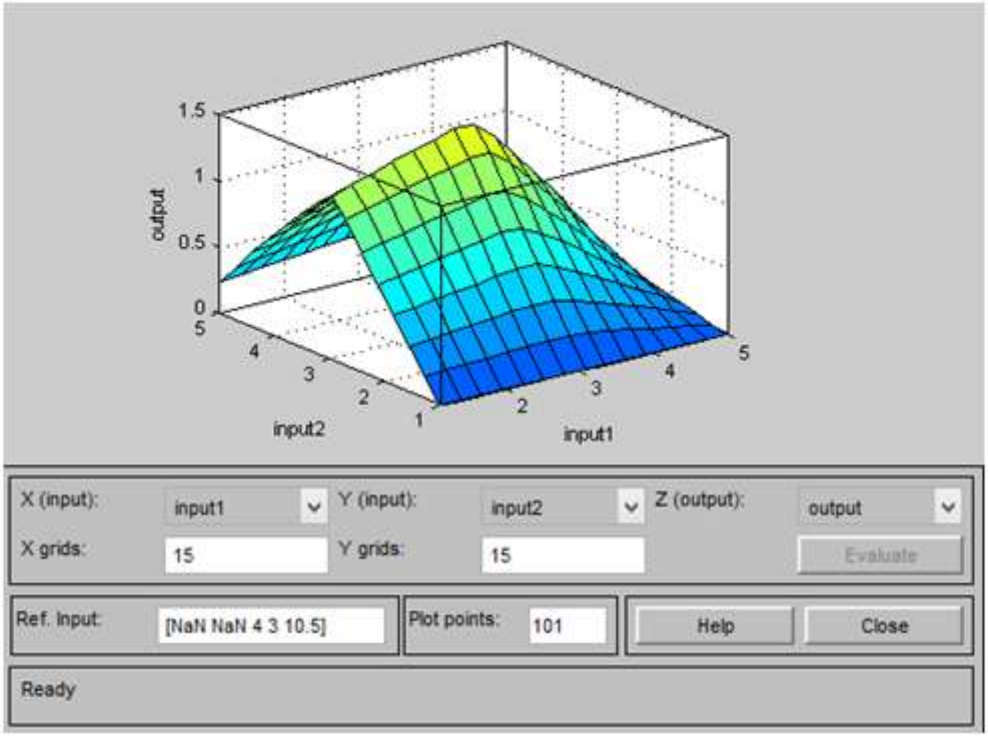

Figure 8: Surface Viewer

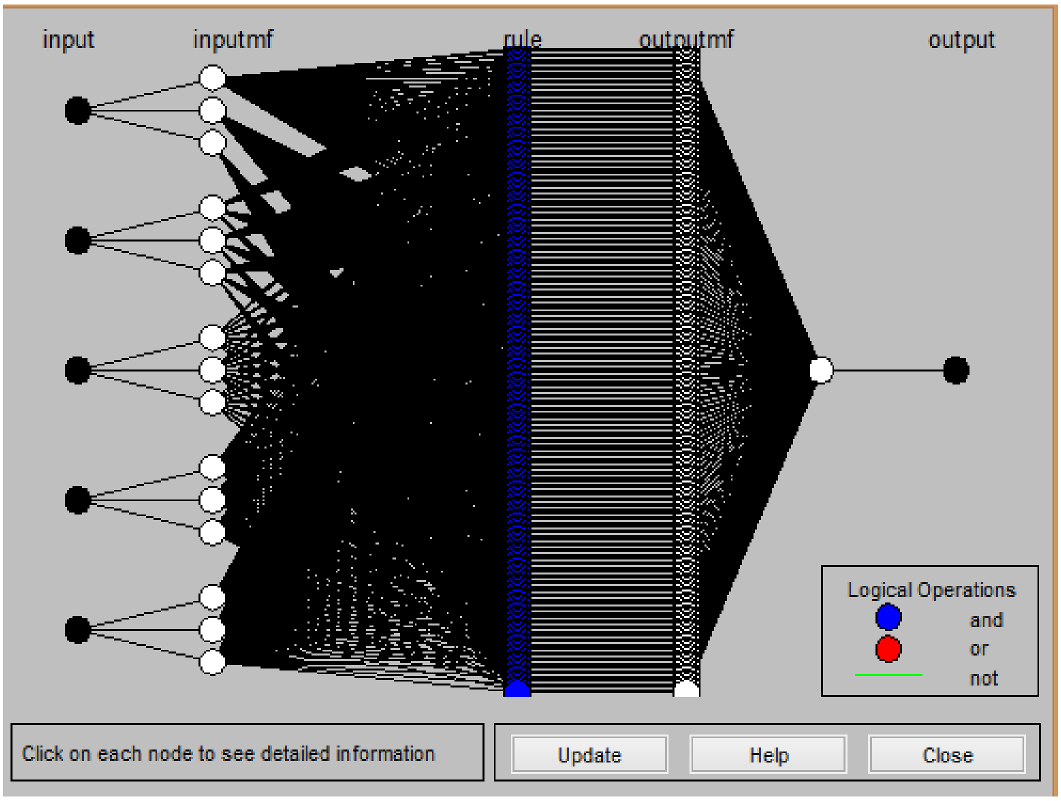

Figure 9: ANFIS Structure

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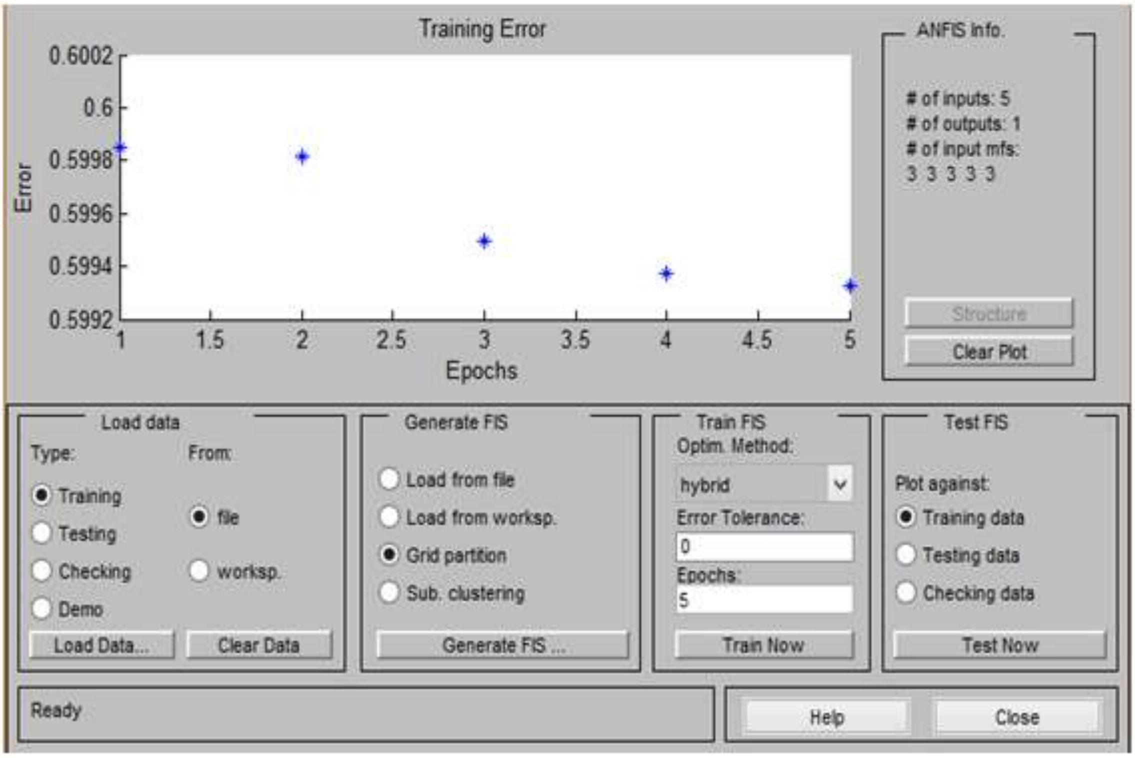

Figure 10: Training Error

4. Results

The data for this study was sourced from the Kaggle data[4] and divided into two segments: training and testing. Specifically, the training dataset constitutes 75% of the overall data, while the testing dataset makes up the remaining 25%. The system undergoes training using 75% of the dataset, and subsequently, the remaining portion (testing dataset) is employed to assess the proposed system. Inputs are provided to the system, generating outputs that are then compared to the actual outputs to calculate metrics such as true positive rate, false positive rate, true negative rate, and false negative rate. Subsequently, the accuracy performance parameter is computed based on these metrics, yielding a value of 95 percent.

5. Conclusion and Future Scope

Based on the outcomes of this research, the proposed system proves to be highly beneficial for the university/college in the assessment of students performance. This approach offers substantial advantages for every student. The implementation of this software requires a computer or machine equipped with MATLAB implementation[3]. To enhance performance, potential future enhancements include the addition of new inputs and outputs to the suggested system. Furthermore, the proposed system could achieve improved outcomes through additional training with expanded datasets.

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