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Integrated Hybrid Intelligent System Approach for Vehicle Damage Prediction

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Abstract

The aim of this paper to develop an integrated hybrid intelligent system for insured vehicle damage prediction confined to Indian legal domain. The system architecture of integrated hybrid intelligent system is modular and the modules are integrated in passively coupled sequential manner. The Rule Based Reasoning (RBR), Fuzzy Case based Reasoning (FCBR) and Neural Networks (NN) are module components of hybrid system. Prior to the actual claim execution process, couple of verification and validation steps need to be processed for loss minimization. Hybrid system has been studied to validate insurance surveyor report and evaluate damage or loss occurred to insured vehicle in an accident using neural network. RBR component is integrated with NN to manage both the static and dynamic rules based on problem scenarios. The Neural Network component facilitates to handle an enormous number of problem cases quickly to provide acceptable accurate responses.

Keywords: Fuzzy Legal Expert System, Hybrid Legal Intelligent System, Legal Intelligent System, Fuzzy Case Based Reasoning System, Hybrid Expert System

INTRODUCTION

Numerous intelligent systems are designed and developed in legal domain areas like income tax law, and civil law etc. Within scope of Indian legal domain, we can find intelligent systems in auto insurance domain, basically in area of insurance underwriting and claim settlement. Before auto insurance claim settlement process, insured vehicle claim data in form of insurance surveyor report is validated for any major variations. A system should be in place to standardize data evaluation that assists in speedy processing of claim and loss minimization. The intelligent system development in Indian legal domain with specific reference to motor insurance has not been investigated much as done in other fields like medical etc. Hence there is need to develop intelligent system on different facets of Indian legal domain with specific reference to motor insurance

Quick overview and challenges faced by existing system is furnished in below steps

1. Once an Accident is reported to Insurance Company, insurer assigns surveyor to collect the accident details from the site.
2. Surveyor collects and prepares 'Insurance surveyor vehicle damage assessment report'.
3. Insurer reviews and approves damage assessment.
4. The major challenge involved here is existing system is proven to subjectivity.

To overcome this challenge, a more rational approach with standardization is required to evolve a good system. The claim processing official can use this system as a standard for comparison while examining the survey report. This is basis for motivation to develop a integrated hybrid intelligent system with below capabilities

a) Validate statute rules through deductive reasoning. Statute rules are Motor Vehicle Act, 1988 which are preliminary validations, the system must pass through.

b) Insured vehicle damage prediction model

c) Retrieving associated legal insurance cases so as to successfully develop a reasonable argument through case based reasoning.

The authors of this study carried out the development of rule based system and case based system which are basically integral modules of Integrated hybrid intelligent system [34].

The insured vehicle damage prediction system is modeled and developed using neural network. This paper explained development process steps involved from requirements capturing to low level design.

RELATED WORK

Title of the paper: A Hybrid Approach to Auto-Insurance Claim Processing System [35].

Objective: In Korea, determination of auto-insurance compensation claim depends on responsibility rate which in turn based on expertise in field of auto-insurance and accident report. However there is lot of inconsistency and uncertainty exists while handling claim. In order to overcome these problems, artificial techniques neural networks and fuzzy logic are incorporated in design process.

Methodology: The problem of usage of restricted and fixed rules for changing situations in auto-insurance domain is

handled by neural network approach. Fuzzy logic is applied to circumvent the problem of uncertainty and ambiguity of expression.

Title of the paper: Integration of Rule Based Expert Systems and Case Based Reasoning in an Acute Bacterial Meningitis Clinical Decision Support System [21].

Objective: The research was focused on the implementation of the adaptation stage, from the integration of Case Based Reasoning and Rule Based Expert Systems.

Methodology: The integration of the CBR and RBR methods in the development of a medical diagnosis.

Title of the paper: Rule-based and case-based reasoning approach for internal audit of bank [22].

Objective: This study presents an integrated audit approach of rule-based and case-based reasoning, which includes two stages of reasoning, i.e., screening stage based on rule-based reasoning and auditing stage based on case-based reasoning.

Methodology: This integrated approach eliminates the drawbacks of RBR and CBR methodologies and provides a better way to handle problems, which combine both inductive and deductive information.

Title of the paper: Fuzzy Indexing and Retrieval in Case-Based Systems [23].

Objective: Approach that integrates fuzzy set concepts into the case indexing and retrieval process.

Methodology: Fuzzy-set-based approach that uses fuzzy membership functions to convert numerical attributes into qualitative terms for indexing and retrieval.

Title of the paper: An integrated approach of rule-based and case-based reasoning for decision support [5].

Objective: The integrated system includes both a case base which stores the past experiences and an explanation mechanism which uses domain theory to generalize the aid cases to cover a broader range of problems.

Methodology: In this research, a new reasoning method is introduced which integrates both case-based and rule-based reasoning approaches. By applying this new approach, problem solvers will be able to capture both explainable and unexplainable expertise from these two reasoning mechanisms and generate more effective plans for decision support.

Title of the paper: Split-Up system: Integrating neural networks reasoning in the legal domain [6].

Objective: This approach has been adopted for the construction of a system known as Split-up which predicts the outcome of property disputes in the domain of Australian family law.

Methodology: Rule based reasoning to be integrated with neural networks.

Title *of* the paper: TPA-EXPERT: A Hybrid Legal Knowledge based System for Indian Legal domain [19].

Objective: The aim of this paper is to develop a legal expert system called TPA-EXPERT for transfer of property act of Indian legal domain. TPA-EXPERT has a simple representation structure which combine time tested rule based and case based approach.

Methodology: An integrated knowledge based system which incorporates the rule based and case based reasoning for transfer of property act of Indian legal domain using VisiRule and Java.

METHODOLOGY

Functional modules involved in Integrated Hybrid Intelligent System are Rule based reasoning (RBR), Case based reasoning (CBR) and Neural Network (NN). The RBR executes three rule sets, one is preliminary Vehicle Act regulations, second one is basic soft frauds and third one is fuzzy induction rules. The Fuzzy CBR supports two types of search techniques. One facilitates end user with list of cases associated with rank/score (between 0 to 1). Second one is enhanced fuzzy query retrieval with application defined alpha cut. The CBR module also generates rules, which can be integrated with RBR. The Neural Network recommends 'extent of damage' parameter only when all basic validations are successfully passed. The flow of control to other modules is based on condition triggers.

The Logic flow is like this: The insurer supplies claim data in the form of excel sheet to the system. The System checks for any violation of Vehicle Act rules and regulations and if no errors encountered, the system checks for any basic soft frauds. The control goes to neural network module for further processing, if validation of basic soft frauds succeeds. And if any validation errors exist, the system control navigates to CBR and searches for relevant case. If suitable case is found, the system alerts the user with message as 'fraud can be suspected'. If it's really fraud or not, further investigation is followed and required. The user can ignore the message and invoke the neural network for predicting the damages. CBR module assists lawyers to look into the relevant cases when considering a particular claim dispute.

Neural Network module picks input parameters like type of accident, vehicle age, vehicle with normal load/overload, speed and few additional parameters and output parameters like bumper, bonnets, radiator, chassis, fuel tank, cabin etc. The NN is trained with these parameters.

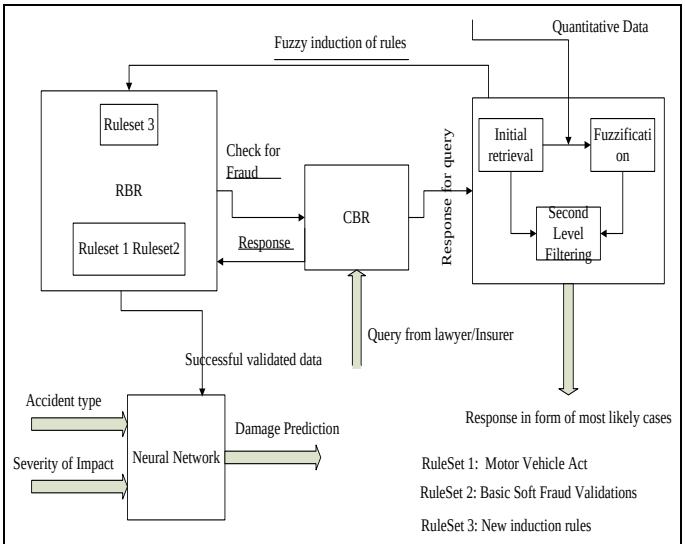

Figure.0.1. Architecture of Hybrid Intelligent System

INSURED VEHICLE DAMAGE PREDICTION SYSTEM THROUGH NEURAL NETWORK

Knowledge Engineering Process

The primary task involved in development process of insured vehicle damage prediction is knowledge engineering process, which further divided into knowledge acquisition and knowledge conceptualisation. Table 1 and Table 2 capture significant input and output parameters from surveyor report. Training data are derived. Training data are derived based on discussion with insurance experts.

Table 1. Input Parameters

Nature of Accident	Accident Type	Collision
		Hit (Fix object)
		Capsizing
		Rollover
Severity of Impact	Age	New (less than 3 yrs)
		Moderate (3 to 10 yrs)
		More than 10 yrs
	Speed	Low (Less than 30 KM)
		Moderate (Less than least of Road condition limit or vehicle stability limit)
		High (More than least Road condition limit or vehicle stability limit)
	Load	Normal
		Overload
	Vehicle Condition	Good
		Bad

Table 2. Output Parameters

Chassis
Fuel Tank
Cabin
Bumper
Bonnets
Radiator
Engine
Steering Column
Suspensers

Technology used for implementation

The Neuroph is lightweight Java neural network framework for development of common neural network architecture. Neuroph supports java API library which correspond to basic Neural Network concepts. Also has nice Graphical User Interface neural network editor to quickly create Java neural network components. It has been released as open source under the Apache 2.0 license. Neuroph supports the following networks: Adaline, Perceptron, Multi Layer Perceptron with Backpropagation, Hopfield, Konhonen, Hebbian, Maxnet, Competitive, Instar, Outstar, Bidirectional Associative Memory (BAM), RBF,network and Neuro Fuzzy Reasoner (NFR).

Algorithm and Flow Chart

The present IHIS uses Back Propagation algorithm to train neural network. The system uses back propagation algorithm to determine the insured vehicle damage prediction by using accident report prepared by insurance surveyor, experienced knowledge of auto insurance experts and the case study. The training data is consisted of type of accident and experienced knowledge of auto insurance experts.

Procedure for training neural network is as follows:

1. Transform the data: The basic step involved here is to transforming data set in binary format (0, 1). Each attribute is replaced with suitable binary combination.
2. Three different data sets need to be created from the initial data set. The first data set will be used for the validation of neural network, the second for training and third for testing the network. Validation set: 10% of instances, Training set: 70% of instances, Testing set: 30% of instances that that do not appear in previous two data sets.
3. Create a Neuroph project with below appropriate parameters
    1. Training set name,
    2. Type of training that is supervised, unsupervised etc

3. Number of input neurons, Number of hidden neurons, Number of output neurons, Neural Network Type that is perceptron, multi layer perceptron, Hopfield etc.
4. Transfer function that is sigmoid, tanh etc
5. Learning rule that is Back propagation, Back propagation with momentum.
4. Create and load the training set. Train the network with parameters like learning rate, momentum etc. Validate the network using a smaller set of data so we can conclude this type of network architecture is suitable and we can train the network with a larger data set.

5. Test the network.

RESULTS AND DISCUSSION

Insured Vehicle Damage Prediction model

In brief, below is the procedure and steps for training a neural network

In order to train a neural network, there are six steps to be made:

1. Transformed Dataset
2. Create a Neuroph project
3. Creating a Training Set
4. Create a neural network
5. Train the network

Transformed Dataset (few instances are pasted here for reference)

Total number of instances is 325

1;0;0;0;1;0;0;1;0;0;1;0;1;0;0;1;0;1;0;0;0;1;0;1;0;0;1;0;1;0;0;0;1;0;0;1;0;0;1;0
1;0;0;0;1;0;0;1;0;0;0;1;1;0;0;1;0;1;0;0;0;1;0;1;0;0;1;0;1;0;0;0;1;0;0;1;0;0;1;0
1;0;0;0;1;0;0;1;0;0;1;0;0;1;0;0;1;0;1;0;0;0;0;1;1;0;0;1;0;1;0;0;0;0;1;0;0;1;0;0;1
1;0;0;0;1;0;0;1;0;0;0;1;0;1;0;0;1;0;1;0;0;0;0;1;1;0;0;1;0;1;0;0;0;0;1;0;0;1;0;0;1
1;0;0;0;0;1;0;1;0;0;1;0;1;0;0;1;0;1;0;0;0;1;0;1;0;0;1;0;1;0;0;1;0;1;0;0;1;0;0;1;0
1;0;0;0;0;1;0;1;0;0;0;1;1;0;0;1;0;1;0;0;0;1;0;1;0;0;1;0;1;0;0;1;0;1;0;0;1;0;0;1;0
1;0;0;0;0;1;0;1;0;0;1;0;1;0;0;1;1;0;0;0;0;1;1;0;0;1;0;0;0;0;1;0;0;1;0;0;1;0;0;1;0
1;0;0;0;0;1;0;1;0;0;0;1;0;1;0;0;1;1;0;0;0;0;1;1;0;0;1;0;0;0;0;1;0;0;1;0;0;1;0;0;1
1;0;0;0;0;0;1;1;0;0;1;0;1;0;0;1;0;1;0;0;0;1;0;1;0;0;1;0;1;0;0;1;0;1;0;0;1;0;0;1;0
1;0;0;0;0;0;1;1;0;0;0;1;1;0;0;1;0;1;0;0;1;0;0;1;0;0;1;0;1;0;0;1;0;1;0;0;1;0;0;1;0

Insured Vehicle Damage Prediction Significant Parameters

List of input attributes

1. Accident Type: Collision (1000), Hit against fixed objects (0100), capsizing on side (0010) and roll over (0001)
2. Age: low (100), moderate (010), high (001)
3. Speed: low, medium and high, same as Age
4. Load: normal load (10), overload(01)
5. Vehicle Condition: Good(10), Bad(01)

List of output attributes (same as age and speed parameter)

1. Chassis: low, medium and high
2. Fuel Tank: low, medium and high
3. Cabin: low, medium and high
4. Bumper: low, medium and high
5. Bonnets: low, medium and high
6. Radiator: low, medium and high
7. Steering: low, medium and high
8. Suspensers: low, medium and high
9. Engine: low, medium and high

S.No	Number of Instances	Number of inputs	Number of outputs	Hidden neurons	Learning Rate	Momentum	Total Error Rate	Iterations
Validation set	56	14	27	24	0.3	0.2	0.01	207
1	308	14	27	23	0.1		0.075	4208
2	308	14	27	18	0.1	0.3	0.13	3635
3	308	14	27	20	0.2	0.1	0.094	7584
4	308	14	27	23	0.1	0.1	0.082	6281
5	308	14	27	25	0.1		0.084	8503
6	308	14	27	25	0.2	0.3	0.046	6590
7	308	14	27	25	0.3	0.2	0.037	5395
8	290	14	27	25	0.5	0.2	0.059	3117
9	290	14	27	24	0.3	0.3	0.084	4738
10	290	14	27	18	0.5		0.127	1734
11	144	14	27	21	0.2	0.3	0.024	8132
12	215	14	27	26	0.3	0.2	0.027	3565
13	215	14	27	24	0.1	0.025	0.022	19217
14	215	14	27	25	0.5	0.7	0.023	4630
15	215	14	27	25	0.7	0.7	0.029	2038

Table 3

Below Figure 3 shows validation done on 56 randomly selected instances out of 325 instances to check for network architecture is suitable for our problem. Below Table 3 shows experimental results carried out for various number of instances and different combinations of number of hidden neurons, learning and momentum parameters. The preferred value is marked yellow shaded. All neural networks listed in Table 3 are configured and trained with configuration: Network Type: Multi Layer Perceptron, Training Algorithm: Back propagation with momentum. Activation Function: Sigmoid Transfer Function.

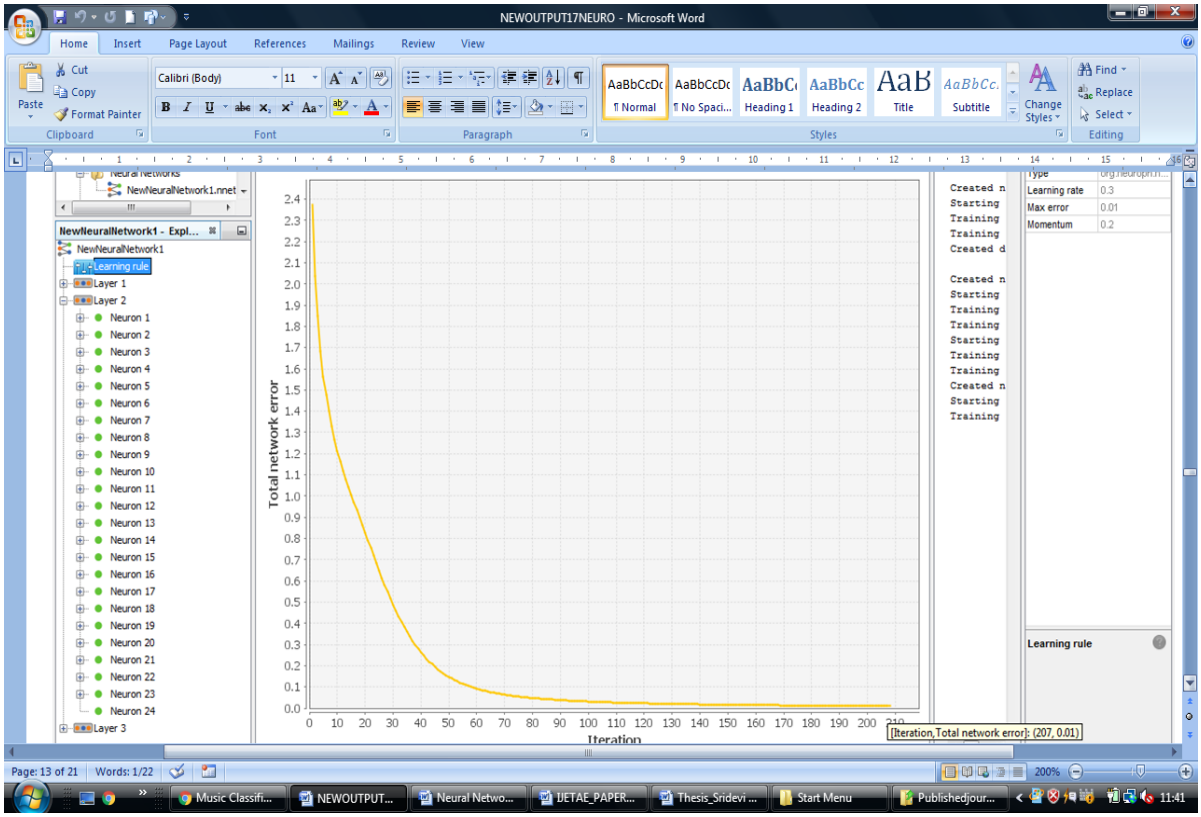

Figure 3. Network Error Graph for Validation Set

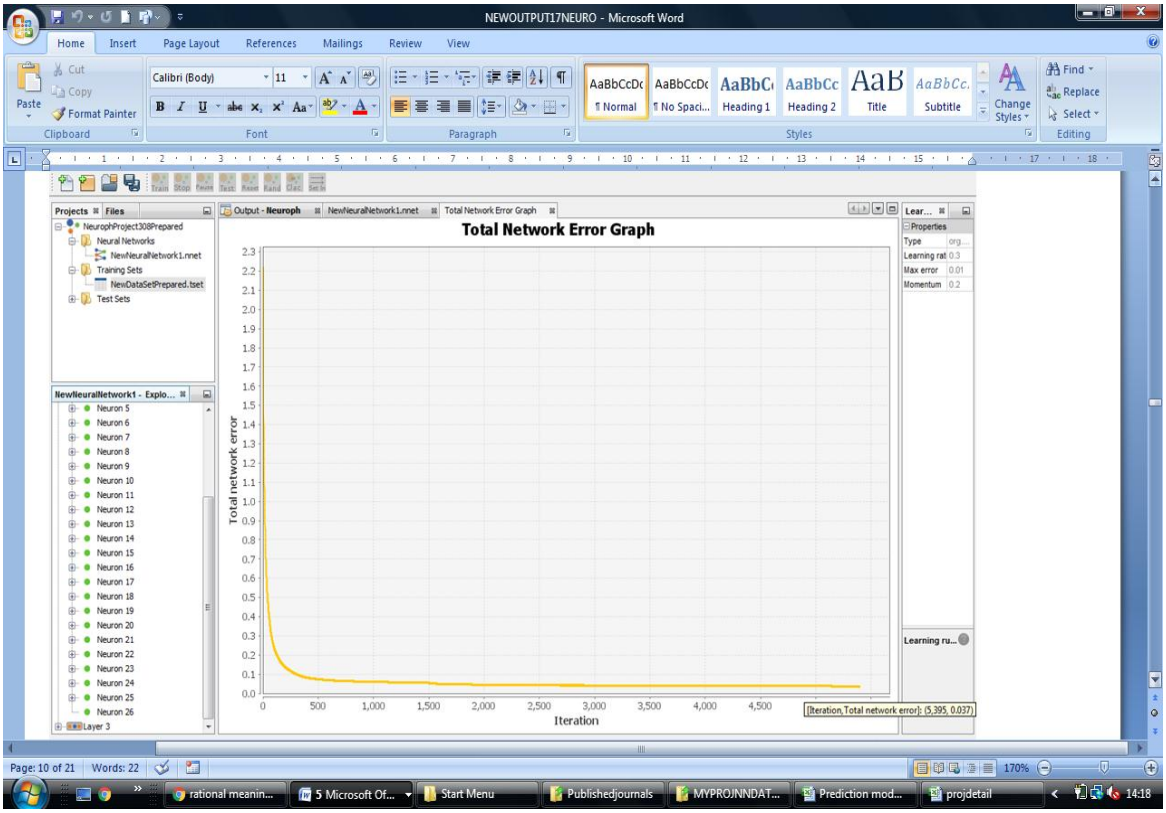

Figure 4. Neural Network Error Graph for Large Set (308 instances data set)

The Figure 4 depicts Total Network Error graph for randomly picked 308 instances from the full set with learning factor 0.3 and momentum 0.2. The Figure 5 below shows the network diagram for large set (308 instances).

We have selected 12 random cases from successfully executed test cases. For each of the 12 selected random cases, we have collected 35 approved surveyor reports. From each approved surveyor report, significant damage parameters are identified. These identified damage parameters are compared with damage output details predicted by the system. Below Table 4 provided the details on individual parameter comparison for case 1. The results are categorised into exact, best and lost fit .as: Best Fit (>=7), Close Fit (>=5) and Loose Fit (<5).

Similar evaluation for all the 11 randomly selected cases was done. The Graphs illustrate Best Fit around 70 to 80 percent, Best and Close fit about 90%. Below Figure 6 shows evaluation of insured vehicle damage prediction graph by comparing with 35 approved surveyor reports. To evaluate the model, we have selected 12 cases randomly from the testing instances. All approved surveyor reports collected are having same input parameters. The primary reason for taking 35 surveyor reports with similar input parameters are, there would be discrepancies upon insurance surveyor expert opinions in preparing same type of insurance surveyor report.

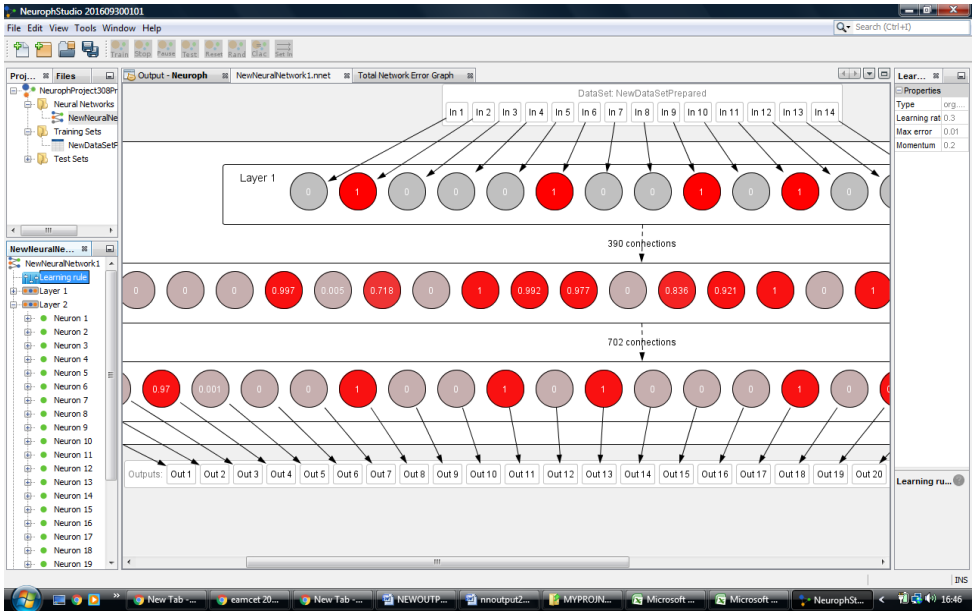

Figure 5. Neural Network diagram for 308 instance data set

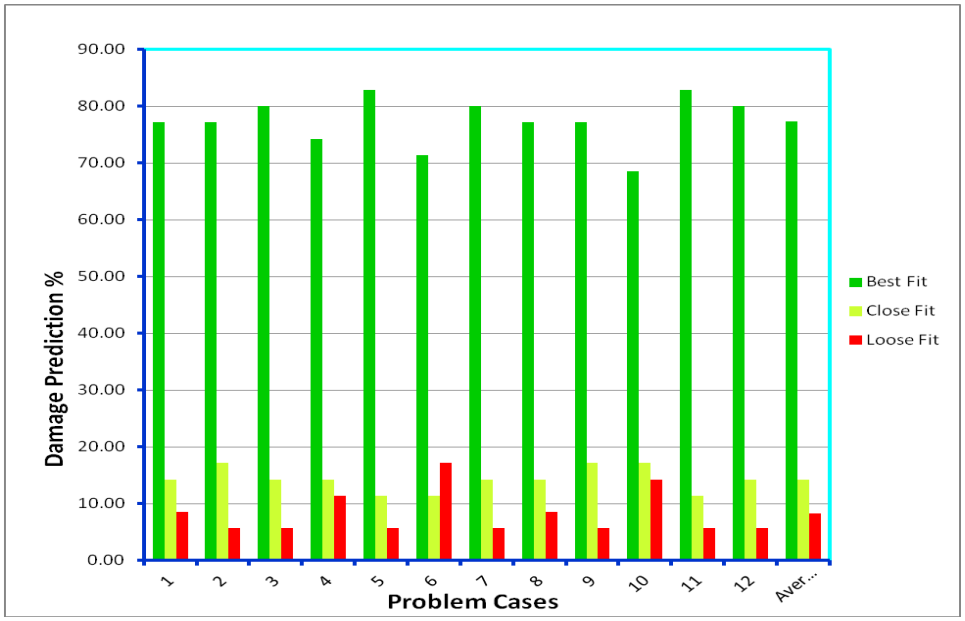

Figure 6. Insured Vehicle Damage Prediction

Table 4. Damage Comparision Matrix for Case 1

Approved Severity Reports	Parm1	Parm2	Parm3	Parm4	Parm5	Parm6	Parm7	Parm8	Parm9	total	Type of Fit
1	1	1	1	1	1	1	1	1	1	9	BF
2	1	1	1	1	1	0	0	1	1	7	BF
3	1	1	1	1	1	1	1	1	1	9	BF
4	1	1	1	0	1	0	0	1	1	6	CF
5	1	1	1	1	1	1	1	0	1	8	BF
6	1	1	1	1	1	1	1	1	1	9	BF
7	1	1	1	1	1	1	1	0	0	7	BF
8	1	1	1	1	1	1	1	1	1	9	BF
9	1	0	1	1	1	1	1	1	1	8	BF
10	0	1	0	1	1	1	1	1	1	7	BF
11	0	0	0	1	0	0	0	1	1	3	LF
12	1	1	1	1	1	1	1	1	1	9	BF
13	1	1	1	1	1	1	1	1	1	9	BF
14	1	0	0	0	1	1	0	1	1	5	CF
15	1	1	0	1	1	1	1	1	1	8	BF
16	1	1	1	1	1	1	1	1	1	9	BF
17	1	0	1	1	1	1	1	1	1	8	BF
18	1	1	1	1	1	1	1	1	1	9	BF
19	1	1	1	0	0	0	0	1	1	5	CF
20	1	1	1	0	0	1	1	1	1	7	BF
21	1	1	1	1	1	1	1	0	1	8	BF
22	1	1	1	1	1	1	1	1	0	8	BF
23	1	1	0	1	1	1	1	1	0	7	BF
24	1	1	1	1	1	0	1	1	1	8	BF
25	1	1	1	1	1	1	1	0	1	8	BF
26	1	1	1	1	0	1	0	0	1	6	CF
27	0	1	1	1	1	1	1	1	1	8	BF
28	1	1	1	1	1	1	1	1	1	9	BF
29	1	0	1	1	1	0	1	1	1	7	BF
30	1	1	0	0	0	1	0	0	1	4	LF
31	1	1	1	1	1	1	1	1	1	9	BF
32	0	0	1	1	1	1	1	1	1	7	BF
33	1	1	1	1	1	1	1	1	1	9	BF
34	0	1	0	1	0	1	1	1	1	6	CF
35	1	0	1	0	0	0	1	0	1	4	LC

CONCLUSION AND FUTURE ENHANCEMENTS

Conclusion:

This work mainly focused on domain analysis and study of components of legal intelligent system for motor insurance claims assessment. This study has shown how AI technologies mainly Fuzzy Logic (FL), Rule Based Expert System (RBR), Case Based Expert System (CBR) and Neural Networks (NN) can be integrated to build hybrid intelligent system framework. This tool can speed up the manual process and most advantageous to insurer and lawyers. Scope of paper is limited to preliminary motor vehicle checks pertaining to Indian legal domain and assessing crucial parameter 'extent of damage'. This model tries to reuse CBR by performing some very basic soft fraud checks. This model hits CBR to check very basic soft frauds and further investigation is required to classify whether it is really fraud or not. Developed and tuned Integrated Hybrid Intelligent System (IHIS) facilitates to speed up review, evaluate and classify the new problem cases based on the library of precedent problem cases. It provides necessary inputs/information needed.

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Future Enhancements:

The application can be made more standardized by introducing many problem scenarios.

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