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Retrieval of e-learning Materials using Adaptive Neuro- Fuzzy Inference System

R.Sarasu[1] and K.K.Thyagharajan[2]
[1]Assistant Professor, Computer Science and Engineering, Dhanalakshmi Srinivasan College of Engineering & Technology, Anna University, Chennai
sarsu_ct1985@yahoo.co.in
[2]Dean, R.M.D Engineering College, Anna University, Chennai
kkthyagharajan@yahoo.com

***Abstract*—The aim of the proposed work is to provide the materials to the students by assisting teacher model using ANFIS. The previous work uses only fuzzy logic, in which same material used to train the students, but in this work according to the knowledge level of the students, different types of materials are provided and trained accordingly by the teacher.**

***Index Terms*— Fuzzy Inference System, fuzzy rules, adaptive learning, ontology, semantic.**

I. INTRODUCTION

Information retrieval is the study of serving the users to find the information that matches their needs. Information retrieval is also process of retrieving desired information from large amount textual data. The documents are indexed and stored in the document collection. The retrieval system should provide the relevant document based upon on user query by ranking of documents. In earlier stages, several information retrieval models has been used to provide the document based user query includes, Vector Space Model, Boolean Model, Statistical Language Model etc., [19].

WWW contains several educational e-learning materials repository. Due to enormous amount of data available as e-learning material, different type of same material, retrieval of relevant e-learning material is a different task. In e-learning system each learner has varied needs, different types of subject knowledge levels; like slow learners, advanced learners whose learning abilities will be varied. The two main issues behind the e-learning system are huge amount of data and the system should satisfy different types of learners needs. The objective of this study is to provide the materials based on the learners need and by identifying their ability. Adaptive learning is one of area in e-learning system, where the materials are provided based on learner needs. Adaptive Learning is an instructive learning method in which uses instruction and instruction resources (like PPT, videos etc.,) according to the need of individual learners. Adaptive learning used in different types of learning systems like hypermedia, Intelligent Tutoring System, Computer Adaptive Testing[12][21].

To satisfy the learners need, the materials which suit them should be provided. The different type of material contains same content. So these duplications can be avoided by ontology. The ontology can be created for different type of materials contains same type of content (i.e) concepts having different meaning come under

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the same category. The ontology contains the set concepts and relationship between the concepts of the learning materials. In literature studies Fuzzy Cognitive Maps(FCM) [12, 14] are used for creating the relationship between the concepts. To detect the semantic of the concept, the relationship between the concepts, ontologies has been used in this study by this FCM are replaced.[5].

This paper focus on providing the materials to the learners based on knowledge level of the student using Adaptive Neuro- Fuzzy Inference System. Adaptive Neuro-fuzzy Inference System or Adaptive Network-based Fuzzy Inference System (ANFIS) is a type of neural network, which works based on fuzzy inference system. Because it combines both neural networks and fuzzy logic principles, it works as a single unit. The inference system will have set of IF–THEN rules and which also have learning capability to approximate nonlinear functions. The ANFIS model builds a fuzzy decision tree to categorize the data into one of 2n linear regression models to minimize errors. Since the ANFIS combines both neural and fuzzy systems, it provides smoothness, adaptability, with the help of back propagation algorithm. It works by translating the prior knowledge into network and then converges to produce the output. The main advantages ANFIS are, the networks converge faster than usual Neural Network, little amount of training is only needed. And this model produces smaller rules than using linguistic labels. [20]. So ANFIS have been used in this study to provide e-learning materials, by assisting the teacher model. The remainder section of the paper is organized as follows. In Section -II related work which consists of ontology creation, fuzzy inference logic, and ANFIS related to e-learning process. In Section – III proposed work of e-learning system is presented. In Section –IV the experiment and discussion is presented. Finally conclusions have been given for adaptation process.

II. Related Work

Generating ontologies from e-learning materials is the first step in retrieve the e-learning materials. There are several techniques have been proposed to generate the ontology from the text. The techniques used to generate the domain ontologies are statistical analysis, natural language processing, web mining, clustering, knowledge acquisition, machine learning [1].Based upon these techniques ontology can be created in automatic and semi-automatic manner. The ontologies are created in semi-automatic manner in [2][4].A.Maedche, et al., [2] Text-To-Onto is a semi-automatic framework used for learning ontologies from domain text, by using machine learning technique. The web data is pre-processed by natural language processing technique. The co-operative modeling paradigm algorithm is for both ontology construction and ontology maintenance. B.Fortuna et al., [4] proposed the OntoGen where the words in the document are weighted and this word weight is used train the SVM classifier for the given categories. The weighting scheme is to adjust the concept discovery method for ontology construction.

The ontologies are created in automatic manner in [5] [6][8][10][11]. R.Navigli et al., [3] created OntoLearn-which uses automatic method for learning ontology from text. The novel idea is the association of both the complex concepts and complex terms .Concepts are detected, taxonomic relation and semantic relation is identified from tourism documents which contains millions of words .This association is done by using structural semantic interconnection algorithm. It extracted 14,383 candidate terms and using these terms 3840 concepts is determined. P.Hasse et al.,[5] proposed Text2Onto- which works based on Probabilistic ontology model .It is used to support knowledge acquirement from text documents. From the text documents, concepts, subclass of relations, general relations , Mereological relations, instances are considered as important things to construct ontologies. These things are extracted by using algorithms relative time frequency, TF-IDF, hearst pattern JAPE expression etc.,. Hou et al., [8]used GRANTO- a graph based ontology construction method .The ontologies are constructed from medical corpus by detecting from entities and properties in the documents. Ontology is created automatically from medical domain corpus based upon graph-oriented approach.

Several fuzzy based concept have been used in field of e-learning to provide the adaptive instruction, assessing the student's performance etc[12][14][15][16]. Maria Virvou et al., [12] used FUZKSD (Fuzzy Knowledge State Identifier), which is similar to the fuzzy which gives relationships between the concepts present in the instruction material. The inference mechanism, dynamically updates the knowledge level of the learner. The novel combination is overlay model combine with stereotype which indicated the concept already known, and concepts yet to be studied. The same material is used for the students for learning and adaptive instruction is given. In web-based educational system, learning performance should be assessed. This assessment has been carried out in [15]. The learning performance can be assessed by four methods such as like Gray Relation Analysis (GRA), k-means clustering, fuzzy association rule mining, and fuzzy

inference mechanism. The students are evaluated based on factors such as the rate of course materials, total read time, learner ability etc.,. Huey-Lng Liu et al.,[16] proposed the graph model is used to represent the learning materials. The proposed model consists of graph, and according individual profile, and according to the personalized learning plan, the materials will be provided. The Quality of Learning is evaluated based on learning rate, learning achievement for 120 students. Xiangfeng Luo et al., used [14] Fuzzy Cognitive Maps have been used for the concept representation. The game –based learning model is proposed by combining teacher model and student model .The limitations of fuzzy cognitive map are it cannot acquire the new knowledge from the existing data and does correct false prior knowledge. The problem can be overcome using Hebbian Learning rule. The driving prototype is used for experiments,two groups of students are evaluated, by studying with game model and without the game model.

Several neuro - fuzzy inference system is used for various problems in literature[13][17][18]. Karthick subramanian etal.,[13] has used Neuro-fuzzy system is used for sequential classification. This neuro fuzzy inference system is called Meta Cognitive component (McFIS), is controlled by the self regulatory mechanism. The meta- cognitive component will takes the decision, what to learn, when to learn, how to learn. The novel idea is when new rule is added, the parameters are detected from the new rule and this rule should be checked with minimum overlapping condition. Shie-Jue tal.,[17] uses Neuro-Fuzzy System used to improve the precision of initial fuzzy rules generated. The fuzzy Neural Networks refines the parameters to improve the performance of fuzzy rules. The inputs are clustered to generate fuzzy rules. The hybrid learning includes the singular value decomposition method and gradient descent method to estimate the error rate and make the machine to converge at a point to reduce the size of search space. Nikola et al.,[18] uses adaptive neural fuzzy inference system named Dynamic Evolving Neural-Fuzzy Inference Systems(DENFIS) used for both offline and online processing .An evolving clustering method is used .New fuzzy rules and updated during the operation of the system.

A. Motivation

The learners have to spend much time in retrieval of required materials on web. In web based -educational system teacher has to provide the material based on the learner knowledge level. To satisfy the leaners and teachers adaptive learning was used in literature. This helps to provide the materials based neuro fuzzy inference system.

III. PROPOSED WORK

The proposed work consists of three modules to provide the material based upon the students ability and their needs. The overall architecture is shown in Fig.1.

i) Ontology construction
ii) Fuzzy Inference System
iii) Adaptive Neuro fuzzy Inference Systems (ANFIS)

A. Ontology Construction

Ontology was defined as the formal, explicit specification of shared conceptualization [8] or ontologies are specification of shared conceptualization of a domain interests that are shared by the group of people. There are wide variety and enormous amount of e-learning materials available in the web for particular subject.

In addition to the number of e-learning documents increases continuously and the contents will changes rapidly. Ontology can be used to represent the knowledge present in the e-learning documents. The concepts and relation between the concepts are extracted from each material and in ontology database. These concepts and relationship are provided to the student. These extracted concepts are given to both teacher model and student model.

B. Fuzzy Inference System

Fuzzy rule-based system also called as Fuzzy Inference System (FIS) which helps take decision in any situation .This inference mechanism generally works based on fuzzy rules. These fuzzy rules are formed from IF-THEN condition along ‘OR’ and ‘AND ‘connectors [22]. The Fuzzy Inference mechanism consist of five blocks such as rule base, membership function database, decision making, fuzzification interface and defuzzification unit[20]. The initial inputs are fuzzified. Fuzzy rules are framed and stored in rule base. The defuzzification unit produces the crisp output. These rules in rule base are used by the dufuzzification block to take the decision by designing system.

This module checks the initial knowledge level of the students, after learning the concept provided in the e-learning materials. The knowledge level, of the student is detected by conducting knowledge level test. The fuzzy Inference System uses fuzzy rules to check which concepts are learned by the students and which concepts are not learned by students. These initial rules help to take the decision whether the concept is understood by the learner or not.

In the initial phase of the Fuzzy Inference System, fuzzy rules generated from the given data set. The student Knowledge Level (KL) is identified based on the initial fuzzy rules. The membership function for fuzzy linguistic variables are given as, µuf, µIK , µk ,µl(unfamiliar, Insufficiently-Known, Known, Learned).In the given document, suppose there are two concepts Ci and Cj in the document Dj then the rule can be written in the form of Eqn.1 and and these rules are stored in the database.

If Ci and Cj are two concepts that are closely related then rule can be,

Rule 1: If KL(Ci) <100% learned then KL(Cj) < 100% Learned since the Ci the pre-requisite concept.---- (1)

Rule 2: If Ci and Cj Known then Cj is Known

Rule 3: If Ci and Cj is unfamilar and Cj is unfamiliar

Rule 4: If Ci and Cj is known and Cj is known……..**RuleN**

The trapezoidal membership function is used for fuzzifying the input and to detect the knowledge level of the student is given by trapezoidal function,

$$\mu ij(xi,) = trapmf\ (xi\ ;aij,\ bij,\ cij,\ dij) \quad \text{------- (2)}$$

(i.e) its derived from the following equations

$$f(x;a,b,c,d) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), o\right) \text{------- (3)}$$

Here a, b, c, d are parameters, where a, d are feet and b, c are called as shoulders of trapezoid function.

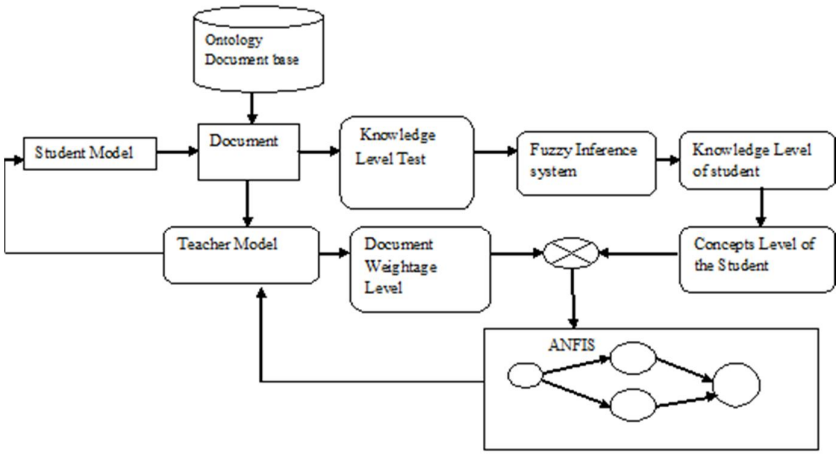


Figure1. Overall Architecture Diagram

For example in Java Programming Language, if suppose concept C_i is datatype and C_j is arithmetic operators then the rule can be formed as follows,

Rule: if C_i is insufficiently- known and C_j is insufficiently-known then knowledge level of writing program using operators will be insufficiently –known.

C. Adaptive Neuro Fuzzy Inference System

ANFIS is a kind of adaptive network that works equivalent to fuzzy inference systems.ANFIS architectures representing both the Sugeno and Tsukamoto fuzzy models [20].The neuro adaptive learning technique provides the fuzzy models, to learn the knowledge present in the input datasets. This learning technique

assists FIS to compute the membership function and its works similar to the neural networks. During learning step of neural networks the membership function will vary. A gradient descent function is used to adjust the parameters in the fuzzy rules. ANFIS uses back-propagation for parameter computation in the parameter estimation [22].

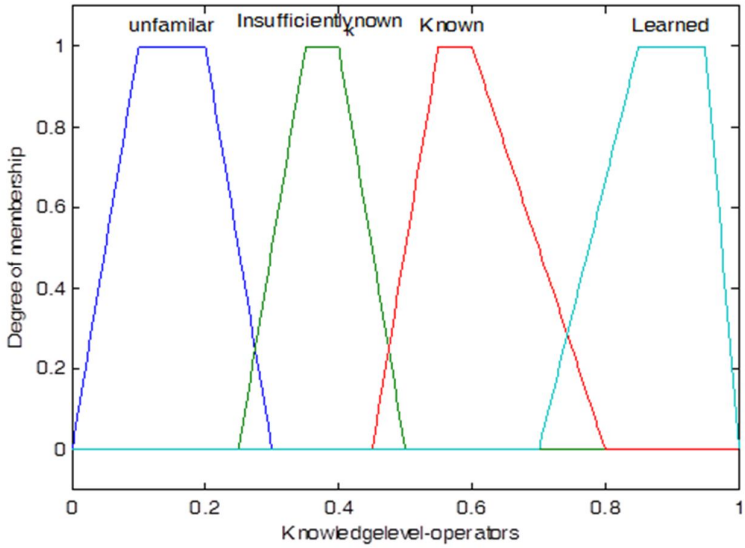


Figure 2. Membership function

The initial fuzzy rules are constructed to identify the concepts which are understood by the student. If the particular concept is not understood by the learner, then ANFIS system will generate the new rules to detect the error rate (concepts that are not understood) and parameters in rules are estimated again .Again the ANFIS will provide the different materials if the target level of the student is not reached. This process will be repeated until the learner satisfaction. This working of ANFIS is shown Fig.3.

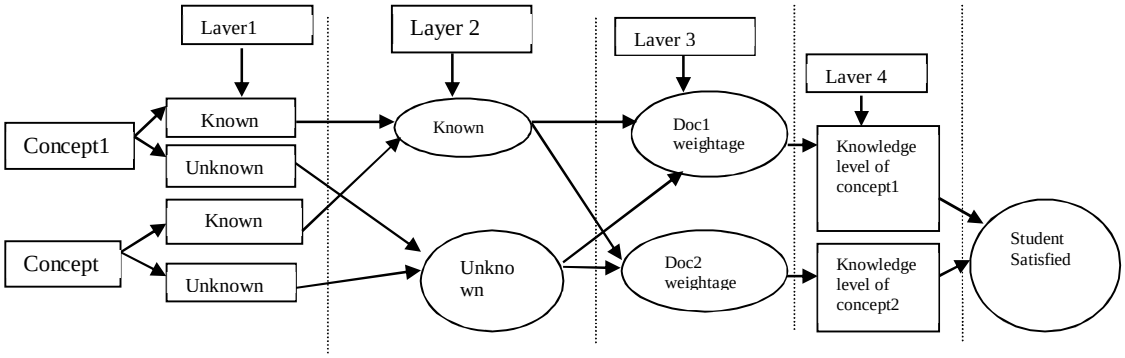


Figure 3. Adaptive Neuro -Fuzzy Inference System

In Adaptive Neuro Fuzzy Inference System, the materials are trained and provided by following steps,
i) The initial fuzzy rules are determined by the Fuzzy Inference System and these rules given as the input to the ANFIS system. For example like R1…Rn. for the concept in the document Di.
ii) These rules are given as the input to the layers present in the neural networks presents in the ANFIS system.
Layer1: This layer is called input layer. It contains the 'n' number of nodes, and 'x' will be the input concept present in the initial rules,
O(i)represent the output from the first layer and the output is written as follows,

$$O(i) = \mu_{A_i}(x) \text{ ------- (4)}$$

where 'A i' will be attributes or fuzzy linguistic variables like learned, unfamiliar, Insufficiently Known, Known.

Layer 2: With the help of output obtained from the input layer, the inputs are fuzzified. The fuzzification process is done again for the concepts. This layer produces the output by calculating the value of gbellmf() membership function

$$O_j(2) = \mu_{ij}(O_i(1)) \text{------- (5)}$$

(i.e) gbellmf(O_i(1),ai,bi,ci)

(i.e) its derived from the following equations,

$$f(x;a,b,c) = \frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}}$$

Layer 3: This layer will work based upon the output obtained from Layer 2. The output obtained by the product of all inputs to this layer to produce the firing strength of rules produced. The weightage of the document is used to strengthen the rule.

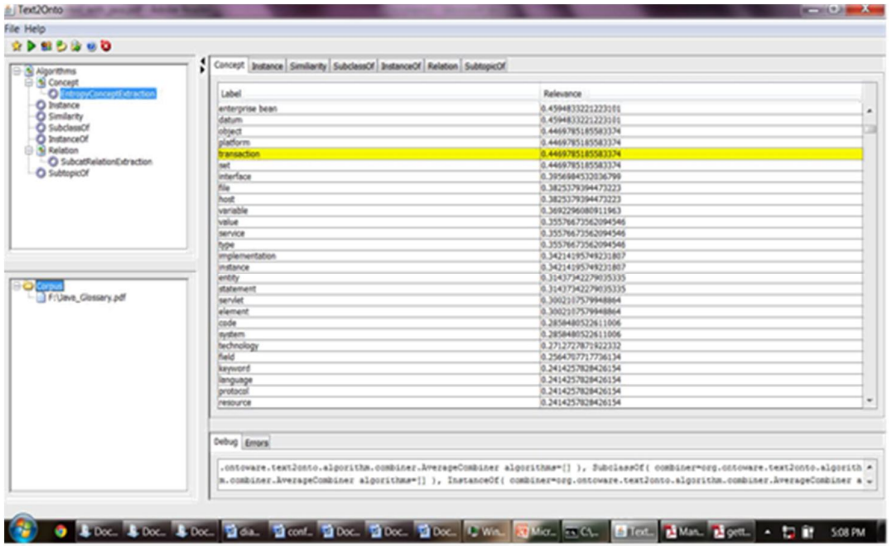
$$O_j(3) = \prod_{i=1}^{n} O_j(2) \text{------- (6)}$$

Layer 4: This layer produces the rules which are defuzzified to get the crisp by centroid method to tell whether the concepts are learned by the student again or not. The knowledge level of the student is detected by conducting knowledge level test.

$$O(4) = \frac{\sum_{j=1}^{n} O_j(3) C_j}{\sum_{j=1}^{n} O_j(3)} \text{ ------- (7)}$$

IV. Experiments and Results

The Ontology is constructed from the Text2Onto tool as shown in Fig.4 and rules are automatically generated from FIS and ANFIS in MATLAB. The student knowledge level about the particular concept is analyzed using fuzzy inference system in MATLAB as shown in Fig.5.



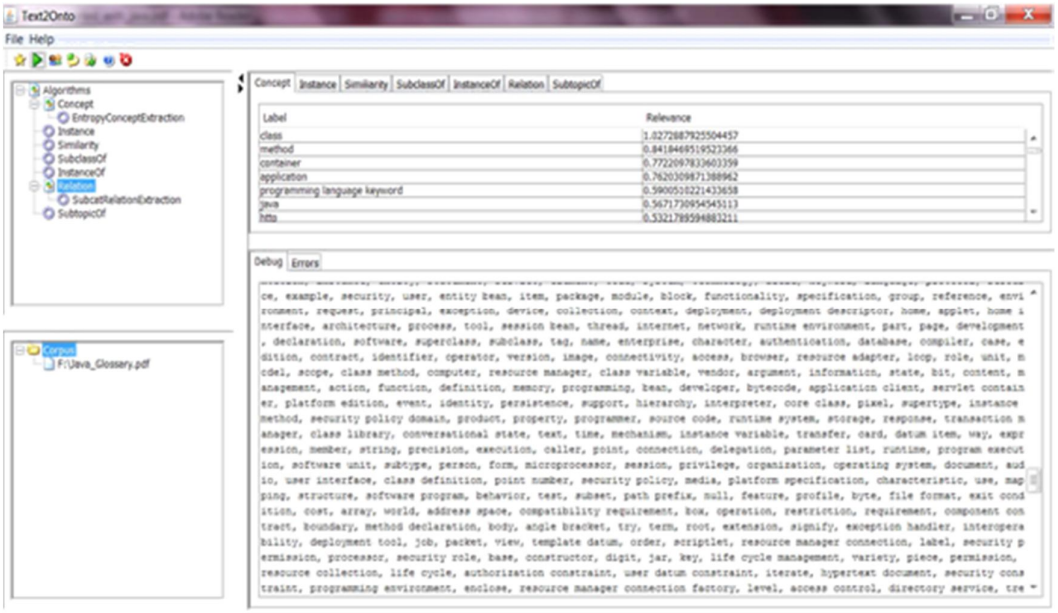


Figure 4. Screenshot from Text2Onto tool

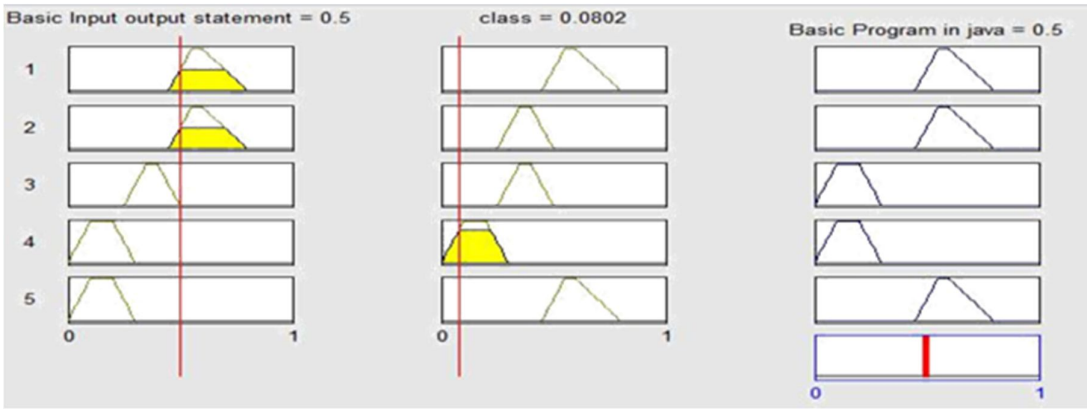


Figure 5. ANFIS rule generation

V. CONCLUSION

Thus this study provides e-learning materials for subjects are retrieved and stored in the ontology base. This is achieved by three computational concepts like Ontology construction, Fuzzy Inference System and ANFIS. The Neural network in ANFIS is trained to identify the knowledge level of the student. If the target level of the concept is not reached, the different materials are provided again to train the students. Thus the materials are provided based upon the learner need which improves the extended use of the e-learning system.

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AUTHORS

Dr. K.K. Thyagharajan obtained his B.E., degree in Electrical and Electronics Engineering from PSG College of Technology (Madras University) and received his M.E., degree in Applied Electronics from Coimbatore Institute of Technology in 1988. He also possesses a Post Graduate Diploma in Computer Applications from Bharathiar University. He obtained his Ph.D. degree in Information and Communication Engineering (Computer Science) from College of Engineering Guindy, Anna University.He has served at various Educational Institutions. He has twenty five years of teaching experience. Since September 2012 he is the Dean (Academic) of R.M.D. Engineering College. He has written 5 books in Computing including "Flash MX 2004" published by McGraw Hill (INDIA) and it has been recommended as text and reference book by universities and Polytechnics. He has published more than 80 papers in National & International Journals and Conferences. He is a grant recipient of Tamil Nadu State Council for Science and Technology. His biography has been published in the 25th Anniversary Edition of Marquis Who's Who in the World. He has been invited as chairperson and delivered special lectures in many National and International conferences and workshops. His current research interests are Multimedia Networks, Content Based Multimedia Retrieval, Mobile Computing, e-learning, Image Processing. He is reviewer for many International Journals and Conferences. He is a recognized supervisor for Ph.D by Anna University Chennai, MS University, JNTU and Sathyabama University.

R.Sarasu completed his B.E degree in Computer Science and Engineering from Prince Shri Venkateswara Padmavathy Engineering college in 2006. She received M.Tech in Information Technology from Sathyabama University 2010. She is at present a Ph.D Scholar in Information Technology from Anna University. Her research areas are Web mining, Web data Extraction, Semantic Based Information Retrieval. She has nine years of Teaching Experience.