International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Estimating Performance of Intelligent Software Systems

Manu Banga, Abhay Bansal, Archana Singh

Abstract*: Reliability is one of the most critical and fundamental aspect while evaluating any software. With the rapid growth in the use of software, the issues concerning the trustworthiness of the software are also increasing. This provides the authors, the motivation to evaluate the software systems fiducially through the implementation of entropy based on the combination weights (CW) methods. These weights are the result of mathematical computation and are based on experts' opinion. The entropy based approach enables the authors to determine the degree of criteria as per experts' judgment and also remove the biasness in the weights, by providing objective weights. On contrary the Analytic Hierarchy Process (AHP) has been considered as principal precise methods for decision making with multiple criteria has been extensively considered in the operations research literature as well as useful to solve countless real-world problems. The result of this research contributes in providing better judgments by imparting decision information to the decision makers and also illustrates the robustness of this approach.

Keywords: Software, trustworthiness, entropy, combination weights, decision judgment

I. INTRODUCTION

With the proliferation in the use of information technology, the society has become dependent on the software systems and products. Software has been playing a crucial role in manufacturing, security, finance, government, business and a lot more but still fails at being trustworthy at all times. In organization computing is present universally. Computing helps ranged based control of the variables of a process immensely. For instance, it is possible to extract data from any process, analyzing them and use of software tools will definitely improve the undergoing process. This study emphasis on analyzing the data obtained from an expert's opinion based on certain criteria. Here the objective is to study those inputs / data in order to extract useful information to improve the process performance of software under consideration. Today, as the software is being widely used, its failure can lead to devastating consequences and also causing disastrous damage [1]. Thus, to evaluating software trustworthiness/performance (ST/SP) which would in return provides the decision makers with more relevant decision information. Several approaches have been proposed for evaluating the software [2, 6, and 9]. These approaches evaluate the software form different aspects and contain basic concepts, terminologies, systems, plans, and software processes. Depending on these researches, criteria for development properties that contribute to the obligation of software, considering it is an all-encompassing property encompassing an arrangement to build reliable software. Thus, in this research, the authors have considered the software assessment process during up gradation or even during transition as a foundation of Multi Criteria Decision Making (MCDM), which comprises of qualitative and quantitative criteria. MCDM deals with two major problems [11, 12]. This paper aims at formulating the software faithfulness when it is operational as an MCDM model. It also presents a novel approach for evaluating the development process utilizing the MCDM methods. The results of the approach in bringing reliable intelligent software systems using criteria's as ranking observed as alternatives. MCDM approaches have been extensively employed for dealing with intelligent software systems selection criteria problems other fields [20, 24]. However, this study has rarely been used in the field of software development from assessment or trustworthiness perspective. Therefore, it is special; software advancement is measured using combined AHP & Entropy approach. In this paper 5 sections are defined as: Section 1 presents introduction of the subject and need of Intelligent Software Systems. Section 2, is on literature review of subject with the conceptualization of the problem. Section 3, provides the overview of process adopted for obtaining the objective of the research. Section 4, elucidates an application in the form of evaluation of software. In Section 5, the results of evaluation are discussed. A final section consists of conclusion and recommendations for the future research in this area.

II. LITERATURE REVIEW

The assessment methodology of anticipated model comprises of the following stages appeared as

A. Criteria Selection
B. Evaluation Criteria weights
C. Applied Hybrid Approach
D. Combined Weighting methods reflects Trustworthiness of software on the basis of criteria

Resource allocation problems have been studied to a great extent in the literature.

Manuscript published on 30 September 2019
* Correspondence Author
Manu Banga*, Ph.D. Scholar, ASET, Amity University, Noida, India, manubanga@gmail.com,
Abhay Bansal, H.O.I. & Professor, Amity University, Noida, India, abansal1@amity.edu,
*Archana Singh, Professor, Amity University, Noida, India, asingh27@amity.edu

Dynamic, mathematical and goal programming are some of the approaches adopted to obtain solutions of optimization problems. Numerous SRGMs have been developed in the literature to minimize the total testing effort expenditures under static as well as dynamic assumption.

During testing, for minimize mean, two resource allocation problems were proposed and solved by Ohetera [20, 24,27]. Yamada et al. [1, 17, 19] considered reliability condition and budget constraint in order to study the allocation problem described by Ohetera and Yamda [14,16]. Xie and Zhang [18] incorporated the Goel and Okumoto [10, 21] model keeping minimum operational failure intensity for distributing total testing time to individual module. Kapur et al. [9, 12, and 14] considered various exponential and S-shaped SRGMs for examining several resource allocation problems in which the faults removed from each module are maximized with the reliability of software. Haung et al. [9,13] discussed optimal testing resource distribution by investigating the results of parameters optimization problem.

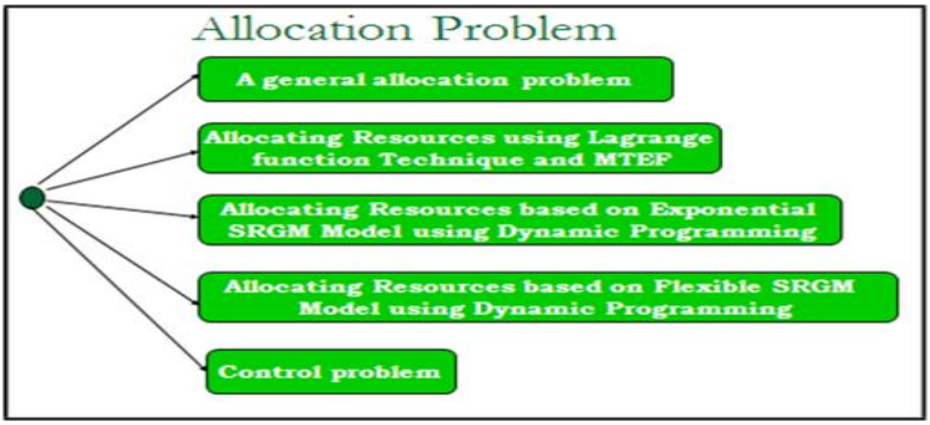

Fig. 1.Resource Allocation in Intelligent Software System Model

Keeping in Mind the primary factors that helps to assess the performance of software, the decision criteria has in use in phase 1, in the next phase the weights are assigned that will contribute to implement the remaining two sections. The first section is to acquire the subjective weights using AHP. Subjective Weights mainly for interpretation of the decision of managers in managing various criteria evaluation. Section two recognizes objective weights, which is appropriate for handling uncertainty [25]. Subsequently, the general weights of criteria are dictated by using a combine weighting strategy [21]. In phase 3, combining of subjective and objective weights are used for acquiring software reliability resource allocation.

III. RESEARCH METHODOLOGY

Exploration on the Greenfield is not an elementary learning of criterion. Steffen et al. considered software's credibility is resolute mostly by accuracy, security and service quality [2, 12, and 6]. Whereas Tan et al. talked about properties that are based on attributes mainly functionality, safety, portability, sustainability and reliability [7, 23].Fenton et. al in their study identify some realistic criteria'sin the form of reliability, ability to learn and operability . Zhao et al. believed that software trustworthiness should be judged by five criteria's; they are availability, reliability, maintainability, security and safety [22, 26]

.

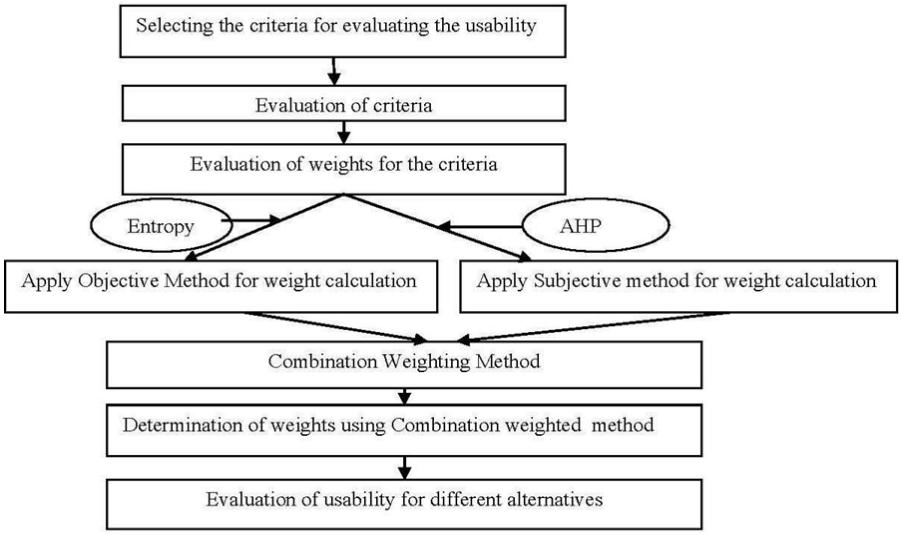

Figure 2: Proposed Approach for evaluation usability of factors

Ground on their study and observation; this work we acknowledged their findings and considering our problem statement we considered New Functionality, Security Threats, Cloud Integration as our criteria to judge the transitional functionality of software as reliable software [1, 3, 13].

Then evaluation criteria are same as identified criteria and mainly based on Interoperability, Ease of use, Security. This section depicts the usage of combined MCDM approach along with weight estimated method [6, 11]. Further, the truthful metric for developed software is applied using simple additive weighting (SAW) method. The objective, subjective and linear combination method for weighting vector as discussed in this section.

Table 1: Identified Criteria

Criteria	Description
New Functionality	A discrete piece of functionality desired by stakeholders, An added functionality has to be able to estimate or it can be properly prioritized, Make it; test it; show it to users; allow them to use it extensively; incorporate their feedback and revise until as perfect as possible.
Security Threats	Security Threats is defined as a risk that can potentially harm computer systems and organization.
Cloud Integration	Cloud Integration is considered as a hybrid approach by where a canonical application core remnant in the platform cloud and the odd pieces of functionality requires scaling shift off to infrastructure clouds.

Goal is to measure Software trustworthiness/performance based on selected criteria's keeping in mind the alternatives. Here in this work we concentrate only on transitional fidelity as a goal by applying a combined approach using criteria's.

IV. EMPIRICAL STUDY

The key quality and reliability criteria for precise assessment are a resultant from all-inclusive examination and discussion with diverse experts from varied areas.

4(a). Weighting Methods:

In any decision-making practice preferred criterion specifically has its own influencing task for software trustworthiness judgment. The coefficient of weight refers to the weights of each criterion in MCDM methods. Unanimously, biased methods agreed on weights solely to decision - maker's inclination, which includes AHP and two way assessment mechanisms [4, 5].Intent methods works on having the same opinion on weights by working mechanically on numerical models without any reflection on the liking of the decision maker, the entropy method falls under this category [8, 18, 23] The subjective weighting method predominantly clarifies the evaluation undoubtedly while the objective one falls short to do so. For that reason, in this work, AHP and its variation and entropy are consistently applied as a combined weighting method.

4(b). Objective Methods

To measure the amount of evidence mathematically, Shannon used the concept of entropy. Entropy is constructed on the plain impression that the evidence is as long as existence of probable events is apparent. Shannon entropy is used for calculating objective weights [26]. As it is based on analytics, makes it a reasonably objective method. It consists of the following steps

1. Construction of data matrix

$$\begin{array}{c} \\ U_1 \\ U_2 \\ \vdots \\ U_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \dots\dots Equ(1)$$

2. Normalize and calculate the entropy value

$$v_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$$

$$N_j = -k \sum_{j=1}^{n} f_{ij} * \ln(f_{ij}) \qquad i = 1,2.\dots\dots m \qquad \dots\dots Equ(2)$$

Where;

$$f_{ij} = v_{ij} / \sum_{j=1}^{n} v_{ij} \text{ and } k = \frac{1}{ln(n)},$$

Objective weight calculated as:

$$w_j^1 = \frac{1-N_j}{\sum_{j=1}^{n}(1-N_j)} where\ j = 1, \dots, n. \qquad \dots\dots Equ\ (3)$$

4(c) Method for Subjective Weighting

Organizations comprehend the prominence of presenting a mount platform and observe to adapt to standards in command to create appropriate arrangement and possessions to discover unlike phase of well-defined processes in the form of performances. Analytical Hierarchical Process (AHP) is an operational device for determining the distinct and constant matching associations in multi-level order arrangements. This one takes a unique feature of seeing the consistency in the judgments. Simple pair-wise comparison of features is approved out now this system. The resulting conclusions are situated cast off to boundary the comprehensive weights of the features measured. AHP is developed by Saaty [27] and addresses how to find out the relative magnitude of a set of criteria [15]. In order to successfully overcome the issues with imprecise and partial information, an approach of two ways assessment mechanism with AHP was incorporated, which guide to exercise an original decision analysis technique so that contentment is painted [17]. In the past, most of the relative weights of system attributes effectiveness were said to be of equal burden. However, in practice, the importance of each attribute in overall helpfulness is not exactly the same [5]. Therefore, a significant numeral of specialists was consulted to answer an AHP questionnaire and the relative weights of various attributes effectiveness can be compared.

4(d) Method for Combination Weighting

Combination weighting techniques associates the objective weights and the subjective weights together. Interestingly evaluating criteria are considered as benefit as well as cost criteria in the light of proper utilization of the methodology

For higher accuracy the better weights are

$$u_{ij} = \frac{max\ v_{ij} - v_{ij}}{max\ v_{ij} - min\ v_{ij}} i = 1..m, j = 1..n \qquad \dots Equ\ (4)$$

reversely

$$u_{ij} = \frac{v_{ij} - min\ v_{ij}}{max\ v_{ij} - min\ v_{ij}} i = 1..m, j = 1..n \qquad \dots Equ\ (5)$$

Now, finally as per Wang et.al .the combination weights gets calculated as

$$W = \sum_{k=1}^{2} \lambda_k w^{(k)} \qquad \dots Equ(6)$$

Where, $w^{(1)}$ and $w^{(2)}$ represents objective and subjective-weights, and $\lambda_k$is linear combination coefficient that has assessed by utilizing Jayne's maximal entropy theory as

$$\lambda_k = \frac{exp\{-[1 + q\sum_{i=1}^{m}\sum_{j=1}^{n} w_j^k(1-u_{ij})/(1-q)]\}}{\sum_{k=1}^{2} exp\{-[1 + q\sum_{i=1}^{m}\sum_{j=1}^{n} w_j^k(1-u_{ij})/(1-q)]\}} \qquad \dots..Equ\ (7)$$

$q$is a balance-coefficient 0< q<1 and $\sum_{k=1}^{2}\lambda_k = 1$

V. RESULTS AND INFERENCES

Assessment Score of Software Systems: This mechanism is observed functionality as good criteria, while the remaining evaluating parameters performance. The mean of Shannon entropy is equal regardless autonomous parameter α. By these standards the variance among every criteria of means are assessed.

The criteria are as follows:

$$ST/SP = \sum_{i=1}^{m} w_i X_i \qquad \dots\dots Equ\ (8)$$

Table- I: Comparison Matrix

Criteria	NF	ST	CI
NF	1	0.33	0.2
ST	3	1	3
CI	5	0.33	1
Sum	9	1.66	4.2

Table- II: Criteria Weights

Criteria	NF	ST	CI	Sum	Avg	Weights
NF	0.11	0.19	0.04	0.35	0.11	11.96
ST	0.33	0.6	0.71	1.64	0.54	54.92
CI	0.55	0.2	0.23	0.99	0.33	33.12
	1	1	1	3	3	100

Table- III: Users Inputs for reliability of Software

Criteria	Weights	Ratings for three individual criteria's				
New Functionality		Very Good(10)	Good(8)	Average (6)	Poor(4)	Very Poor (2)
NF	11.96	0.5	0.3	0.2	0	0
ST	54.92	0.1	0.3	0.6	0	0
CI	33.12	0.3	0.3	0.2	0.2	0
Security Threats						
NF	11.96	0	0.3	0.5	0.2	0
ST	54.92	0.4	0.4	0.1	0.1	0
CI	33.12	0.2	0.3	0.4	0.1	0
Cloud Integration						
NF	11.96	0	0.1	0.5	0.3	0.1
ST	54.92	0.7	0.2	0.1	0	0
CI	33.12	0.3	0.4	0.2	0.1	0

Table IV: Calculating CI of Identified Criteria's

Criteria	NF	ST	CI	3rd Root of the product		Priority Vector
NF	1	0.2	0.2	0.04	0.341	0.089
ST	5	1	3	15	2.466	0.6617
CI	5	0.33	1	1.66	1.185	0.2996
Sum	11	1.53	4.2		3.99	1
					λmax	3.13

Table V: Subjective Value of Criteria

Criteria	NF	ST	CI
NF	8.6	7	7.4
ST	6.2	8.2	7.2
CI	5.2	9.2	7.8
Sum	20	24.4	22.4

Table VI: Normalized Value: The values are normalized using Equation 3

Criteria	NF	ST	CI
NF	0.43	0.28	0.33
ST	0.31	0.33	0.32
CI	0.26	0.37	0.34

Table VII: Entropy Base Objective weights

	NF	ST	CI
Ni	0.97	0.99	0.99
1-Nj	0.02	0.005	0.0005
w1(j)	0.76	0.21	0.019

Table VIII: Combined Weights

Combined Weight	NF	ST	CI	Total
Combined Weight	0.438	0.388	0.192	1
Objective Weight	0.756	0.211	0.0192	1
Subjective Weight	0.12	0.54	0.34	1
λobj	0.482			
λsub	0.518			

Table IX : Fidelity of Software Systems

Final Outcome	0.51	NF	51
	0.36	ST	36
	0.53	CI	53

VI. CONCLUSION

Performance /Trustworthiness of software is calculated in the range of [0, 1], with aim to attain a trustworthiness indicator of 1 meaning 100 % software reliability without any failure. It is very apparent that cloud integration plays the largest part during operational transitional period. The study can be performed for diverse types of intelligent software Systems. On the other hand, parameters and weights may change accordingly. Consequently, the goal can be determined and presented as: Cloud Integration > New Functionality > Software Security is the well-placed parameters for measuring transitional trustworthiness of software. During development software mostly subjective weights are considered to evaluate fidelity. In the present paper, a combined weight assigning method has proposed where entropy approach forms the basis of the computational building block. The consolidated approach comes about as the transformation is the primary contributor to the evaluation of the reliability of software. This proposed combined weight approach; the subjective and objective weights are combined based on maximizing the variance, as here different dimensions of each attribute are considered.

REFERENCES

1. J. B. Michael, J. M. Voas, and R. C. Linger, 2nd National Software & Workshop series (NSS2) Report: Trustworthy Systems Workshop Report, <http://www.cnsoftware.org/nss2report/>, 2004.
2. S. Becker, M. Boskovic et al, “Trustworthy Software Systems: A Discussion of Basic Concepts and Terminology”, ACM SIGSOFT Software Engineering Notes, vol. 31, no. 6, pp. 1-18, November 2006.
3. W. Hasselbring and R.Reussner, “Toward trustworthy software systems”, IEEE computer, vol. 39, no. 4, pp. 91 92, April 2006.
4. K. Liu, Z. G. Shan, J. Wang et al, “Overview on major research plan of trustworthy software”, Bulletin of National Natural Science Foundation of China, vol. 22, no. 3, pp.145-151, 2008. (in Chinese)
5. D. L. Parnas, J. Schouwen, and S. P. Kwan, “Evaluation of safety critical software”, Communications of ACM, vol. 33, no. 6, pp. 636-648, June 1990.
6. B. Steffen, H. Wilhelm, P. Alexandra et al, “Trustworthy software systems: a discussion of basic concepts and terminology”, ACM SIGSOFT Software Engineering Notes archive, vol. 31, no. 6, pp. 1-18, November 2006.
7. T. Tan, M. He, Y. Yang, Q. Wang, and M. S. Li, “An Analysis to Understand Software Trustworthiness”, The 9th International Conference for Young Computer Scientists, pp. 2366-2371, 2008.
8. Y. Y. Yuan, Q. Han, “Data Mining Based Measurement Method for Software Trustworthiness”, Proceedings-2010 International Symposium on Intelligence Information Processing and Trusted Computing (IPTC 2010), pp. 293-296, December 2010.

9. H. P. Zhang, F. D. Shu, Y. Yang, X. Wang, and Q. Wang, "A fuzzy based method for evaluating the trustworthiness of software processes", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 6195, pp. 297-308, 2010.
10. L. Zhu, A. Aurum, I. Gorton, and R. Jeffery, "Tradeoff and sensitivity analysis in software architecture evaluation using analytic hierarchy process", Software Quality Journal, vol. 13, no. 4, pp.357-375, December 2005.
11. T. C Wang and H. D. Lee, "Developing a fuzzy TOPSIS approach based on subjective weights and objective weights", Expert Systems with Applications, vol. 36, no. 5, pp. 8980-8985, July 2009.
12. Y. J. Wang and H. S. Lee, "Generalizing TOPSIS for fuzzy multiple criteria group decision-making", Computers and Mathematics with Applications, vol. 53, pp. 1762-1772, April 2007.
13. S. W. Hsiao and J. R. Chou, "A Gestalt-like perceptual measure for home page design using a fuzzy entropy approach", International Journal of Human-Computer Studies, vol. 64, pp. 137-156, February 2006.
14. İ."Performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods", Expert Systems with Applications, vol. 36, pp. 702-715, January 2009.
15. C. Fausto, "Fuzzy TOPSIS approach for assessing thermal-energy storage in concentrated solar power (CSP) systems", Applied Energy, vol. 87, no. 2, pp. 496-503, February 2010.
16. H. S. Gao, J.X. Ran, Y.Q. Sun, Risk evaluation of communication network of electric power based on improved FAHP, Systems Engineering - Theory & Practice, vol. 28, no. 3, pp. 133-138, 2008. (In Chinese
17. T. Y. Hsieh, S. T. Lu, and G. H. Tzeng, Fuzzy MCDM approach for planning and design tenders selection in public office buildings, International Journal of Project Management, vol. 22, no. 7, pp. 573-584, October 2004.
18. S. S. Kima, I. O. Yang, M. S. Yeo, and K. W. Kim, "Development of a housing performance evaluation model for multi-family residential building in Korea", Building and environment, vol. 40, no. 8, pp.1103-1116, August 2005.
19. P. A. Morteza, "Project selection for oil-fields development by using the AHP and fuzzy TOPSIS methods", Expert Systems with Applications, vol. 37, no. 9, pp. 6218-6224, September 2010.
20. K. K. Pochampally, S. M. Gupta, and S. V. Kamarthi, Evaluation of production facilities in a closed-loop supply chain: a fuzzy TOPSIS approach. Proceedings of the SPIE International Conference on Environmentally Conscious Manufacturing III, Providence, Rhode Island, pp. 125-138, October 2003.
21. C. T. Tsao, "Evaluating investment values of stocks using a fuzzy TOPSIS approach", Journal of Information & Optimization Science, vol. 24, no. 2, pp. 373-396, 2003.
22. S. H. Tsaur, T. Y. Chang, and C. H. Yen, "The evaluation of airline service quality by fuzzy MCDM", Tourism Management, vol. 23, pp. 107-115, April 2002.
23. T. C. Wang and T. H. Chang, Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment, Expert Systems with Applications, vol. 33, no. 4, pp. 870-880, November 2007.
24. N. E. Fenton and S. L. P fleeger, Software Metrics: A Rigorous and Practical Approach, Second Edition. Beijing: China Machine Press, 2004. (in Chinese)
25. L. A. Zadeh, "Fuzzy sets", Information and Control, vol. 8, pp. 338-353, 1965.
26. M. Z. Naghadehi, R. Mikaeil, and M. Ataei, "The application of fuzzy analytic hierarchy process (FAHP) approach to selection of optimum underground mining method for Jajarm Bauxite Mine, Iran", Expert Systems with Applications, vol. 36, no. 4, pp. 8218- 8226, May 2009.
27. T. L. Saaty, The analytic hierarchy process. New York: McGraw- Hill, 1980.

UTHORS PROFILE

Manu Banga, Ph.D. Scholar (CSE), ASET, Amity University Noida. He has done M. Tech and B.Tech and published various papers in conference and journals.

Dr. Abhay Bansal, Jt. Head ASET / Director, DICET, HOI. ASET, Amity University, Noida, His area of research is data mining, big data, and software engineering. He guided more than 15 Ph.D. scholar He is life member of ACM, IEEE, CSI & IET.

Dr. Archana Singh, Ph.D. (CSE), M.Tech(CSE). She is working as Professor at ASET, Amity University, Noida Her area of research is data mining, big data, software engineering. Presently she is Ph.D. guide of 8 students She is life member of ACM, IEEE, CSI & IET