International Journal of Computing and Digital Systems
ISSN (2210-142X)
Int. J. Com. Dig. Sys. #, No.# (Mon-20..)

Fuzzy Model of NP-Hard Problem: Uncertainty Causes for Identifying Best Goalkeepers

P S Metkewar[1] , Nilkanth Mukunde Deshpande[2] , Syed Irfan Yaqoob[1]

[1]School of Computer Science and Engineering, Dr. Vishwanath Karad MIT World Peace University, Pune, Maharashtra, INDIA.
[2]Department of Artificial Intelligence and Machine Learning, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Pune Maharashtra, INDIA.
pravin.metkewar@mitwpu.edu.in, nilkanth.deshpande@sitpune.edu.in, syed.irfan@mitwpu.edu.in

Correspondence: nilkanth.deshpande@sitpune.edu.in

Abstract: Computational issues have been sorted in feasible, to some extent resolvable and unsolvable. Classes including P, NP, NP-complete and NP-Hard are utilized to group the given issue in light of intricacy of the issue. As of late numerous issues have been demonstrated to be NP-Hard in the space of different games particularly football match-up. Obviously we have found that recognizing best goalkeepers' concern has been neglected. In this issue, "Distinguishing best goalkeepers" from a bunch of players is troublesome and testing. Bit by bit numerical plan have been consolidated for the said NP difficult issue mathematically. Fuzzy models or fuzzy sets are numerical method for addressing dubiousness and uncertain data (consequently the term fuzzy). These models have the capacity of perceiving, addressing, controlling, deciphering, and utilizing information and data that are ambiguous and need assurance. Here authors have emphasized on identifying causes of uncertainty in order to find out best goalkeepers from the data set. Have validated four different parameters including linguistics terms, overlapping in the distribution of rules, parameter conversion to the triangular membership function and optimized rules. Proposed method have achieved to reduce 88% uncertainty with the help of rule optimization by setting up the experiment in the Fuzzy Inference System (FIS) under Mamdani Method.

Keywords: Football Players, Features, NP-Hard problem, Membership Function, Fuzzy Model, Fuzzy Inference System (FIS).

1. Introduction

In software engineering, there exist a few issues whose arrangements are not yet found, the issues are separated into classes known as Intricacy Classes. In intricacy hypothesis, an Intricacy Class is a bunch of issues with related intricacy. These classes assist researchers with gathering issues in view of how long and space they expect to tackle issues and check the arrangements. It is the part of the hypothesis of calculation that arrangements with the assets expected to take care of an issue. The normal assets are existence, meaning how long the calculation requires to tackle an issue and the relating memory utilization. The time intricacy of a calculation is utilized to portray the quantity of advances expected to tackle an issue, yet it can likewise be utilized to depict what amount of time it requires to check the response. The space intricacy of a calculation portrays how much memory is expected for the calculation to work. Intricacy classes are helpful in coordinating comparable kinds of issues.

What is the NP-Complete Issue? Some random issue X goes about as NP-Complete when there exists a NP issue Y-so the issue Y gets reducible to the issue X in a polynomial line. This implies that a given issue can become NP-Complete assuming it is a piece of NP-Hard as well as NP Issues.

A. Procedure to identify the problem is NP Hard or not.

A issue is NP-hard in the event that a calculation for addressing it very well may be converted into one for taking care of any NP-issue (nondeterministic polynomial time) issue. NP-hard in this manner signifies "in some measure as hard as any NP-issue," despite the fact that it may, truth be told, be more earnestly.

B. Karp's reduction (polynomial time reduction):

E-mail:author's email

For a choice issue X to a choice issue Y ought to do the going with given a model x of X, it conveys an event y of Y. It runs in time polynomial. Answer to x YES if and if reaction to y is YES.
In computational intricacy hypothesis, a polynomial-time decrease is a strategy for taking care of one issue utilizing another. Polynomial-time decreases are habitually utilized in intricacy hypothesis for characterizing both intricacy classes and complete issues for those classes.

C. Venn diagram
This picture will give you an understanding about the various sorts of NP issues and there connection with one another. We will talk about the diagram exhaustively beneath.

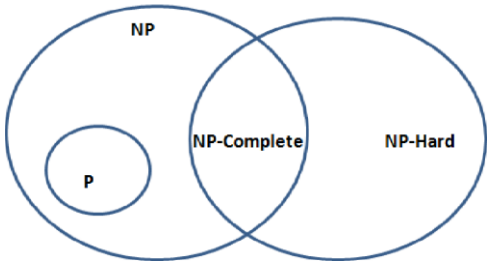


Figure 1: NP Hard problems: Adapted from the source (opengenus.org)

Ponder NP issue as the base set, i.e., just, a set involving those issues which have polynomial time plans yet using non-deterministic estimations. The district named P here is the course of action of polynomial time issues, i.e., those issues for which estimations exist that can handle it in polynomial time. Note that this region is a subset of NP issues. The issues in P were once in NP i.e., they had non-deterministic computations, but we had the choice to disentangle them hence these issues became P. NP complete issues are the assembly district of NP issues and NP-Hard issues. NP complete issues are those issues that gain a few polynomial experiences plan anyway this is surmised using a non-deterministic estimation. If a NP-Hard issue does not have a non-deterministic computation, then, it is not NP gotten done, it remains NP Hard. Right when there exists a deterministic computation for the NP issue, it is named P issue. Right when there exists a non-deterministic estimation for the issue, it is named NP complete. Note that NP approaches the base class of many issues except for some NP-Hard issues. You can find in the diagram over that there is a piece of NP-Hard issues that does not fall in the NP locale.

The major objective of this paper is to provide solution for NP Hard problem which mathematical model was demonstrated in the section 3. Even two different corollaries associated with the NP hard problem has been derived. Another aspect is to identify the causes of uncertainty while setting up the experimentation through Fuzzy Inference System (FIS) and its impact associated with

- linguistics terms,
- overlapping in the distribution of rules,
- parameter conversion to the triangular membership function and
- optimized rules

has been observed.

Here section 1 completely focused on introduction part of the paper that covers procedure of identifying NP hard problem and polynomial time reduction. Literature review or related work covered in section 2. In section 3 mathematical background of NP hard problem is discussed. Section 4 have emphasized on Proposed Methodology with respect to Fuzzy Model for Identifying Uncertainty Causes. Conclusion and future scope has been enclosed in section 5.

II. Related Work

[1] have focuses on the challenges of designing practical algorithms for learning from examples. It identifies three major optimization problems in this context:

1- **Smallest Feature Subset Selection:** Finding the smallest subset of features that still allows for effective learning from examples.
2- **Smallest Decision Tree Induction:** Creating a minor decision tree to represent the learned knowledge efficiently.
3- **Smallest k-DNF Induction:** Constructing the smallest k-DNF (Disjunctive Normal Form) to represent the learned knowledge.

The author demonstrates that all these optimization problems are NP-hard, meaning that efficiently finding exact solutions for them is computationally infeasible. To address these challenges, the author introduces new greedy algorithms as potential solutions for these problems. These algorithms aim to provide practical and efficient approaches for learning from examples in the presence of these optimization hurdles.
[2] have explores the computational complexity of polygon decomposition problems, which is significant to computational geometry and syntactic pattern recognition researchers. The study focuses on three specific polygon decomposition problems: finding minimum decompositions of a polygonal region into potentially

overlapping convex, star-shaped, or spiral subsets. The consideration includes the presence of holes in the polygonal area. The author demonstrates that all three polygon decomposition problems are NP-hard, indicating that efficient algorithms for solving them are unlikely to exist. The NP-hardness proofs are established by transforming the problems into Boolean three-Satisfiability, a known NP-complete problem. As a result, these polygon decomposition problems are challenging from a computational standpoint. In addition to presenting the NP-hardness results, the author also discusses several open problems related to polygon decomposition, highlighting areas that require further research and investigation. These available problems offer opportunities for advancements in computational geometry and pattern recognition.

[3] have addresses the issue of sparse approximation, which is relevant in various applications and often involves solving a constrained or penalized ℓ 0 minimization problem. The ℓ 0 minimization problem is known to be NP-hard, making it computationally challenging. The paper presents a revised analysis of the NP-hardness of the penalized ℓ 0 problems, proposing a new proof based on Natarajan's construction from 1995. This further proof provides insights into the computational complexity of the ℓ 0 minimization problem with penalization, shedding light on the difficulty of finding solutions efficiently. Furthermore, the author extends the analysis to consider ℓ 0 minimization problems with non-negativity constraints. It proves that even with these constraints, the problem remains NP-hard, suggesting that the additional restriction of non-negativity does not significantly reduce computational complexity. Overall, the author contributes to understanding the computational hardness of sparse approximation problems and highlights the challenges associated with solving ℓ 0 minimization problems, both with penalization and non-negativity constraints.

[4] have address the direct requesting issue and propose a deterioration strategy utilizing the Fourier change. They demonstrate the way that the goal capability of the direct requesting issue can be parted into two parts: one that has a place with a P issue (feasible in definite polynomial time) and one more connected with a NP-difficult issue (computationally testing). By decaying the issue along these lines, they present a careful polynomial time calculation to settle the P part, while the NP-hard part stays challenging to effectively address. Utilizing this decay, the creators investigate the way of behaving of various useful calculations that depend just on unilabiate data. They explore how these calculations perform when the issue changes from a P issue to a NP-difficult issue. The creators lead explores different avenues regarding decreased aspects to assess this, where the ideal arrangements are known. They appoint various loads to the NP-hard part while keeping the significance of the P part fixed. This permits them to evaluate the effect of the NP-hard part on the exhibition of the productive calculations. This reference presents an original way to deal with tackle the straight requesting issue by separating it into reasonable and testing parts. By assessing the way of behaving of different calculations under various settings, the creators gain bits of knowledge into how these calculations handle the progress from polynomial-time resolvable issues to NP-difficult issues.

[5] have propose a hybrid approach combining local search and genetic algorithms. They view local search as a form of learning that occurs over an individual's lifetime. The objective is to enhance the efficiency and effectiveness of the genetic algorithm by incorporating learning mechanisms. There are two main ways in which learning is integrated into the hybrid algorithm: Lamarckian evolution and the Baldwin effect. Lamarckian development refers to the idea that individuals can acquire new traits or knowledge during their lifetime and pass them on to their offspring genetically. The Baldwin effect, on the other hand, suggests that learning can influence the evolutionary process by allowing individuals to adapt better to their environment.

To evaluate the impact of learning in the hybrid algorithm, the authors vary the proportion of the population that undergoes learning. They systematically study different scenarios to find the optimal balance between knowledge and traditional genetic processes. Their findings reveal that the quality of solutions improves significantly when the proportion of the population undergoing learning reaches or exceeds a critical level. This suggests that incorporating learning mechanisms into the genetic algorithm leads to better solutions and enhances the overall performance of the hybrid approach.

[6] have introduces a new algorithm called the "Shaking Optimization Algorithm" to address the limitations of traditional Evolutionary Computations Algorithms (ECs) such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Simulated Annealing, and Tabu Search. These traditional algorithms are unsuited for fine-tuning structures because they must consider conventional heuristics. However, in most NP-hard problems, the best solution is often not wholly random and follows specific rules or heuristics. The proposed Shaking Optimization Algorithm adopts the general approach of Evolutionary Computations but incorporates different heuristics during the evolution process of finding a solution. This allows the algorithm to consider and utilize additional problem-specific rules and heuristics during optimization, making it more effective for NP-hard problems. The algorithm's performance is tested on Job Shop Scheduling problems (JSS), a well-known NP-hard problem domain. The results demonstrate that the Shaking Optimization Algorithm outperforms traditional GA, PSO, Simulated Annealing, and Tabu Search algorithms when applied to JSS, providing more promising and efficient solutions. This highlights the advantages of incorporating problem-specific heuristics into the evolutionary computation process for fine-tuning structures and solving complex NP-hard problems.

[7] have tells the concept of t-bounded instance complexity of a string x concerning a set A, denoted as ic/sup t/(x: A), is introduced in this paper. This complexity measures the size of a minor program (akin to a Turing machine) that can correctly decide x within a time-bound t while making no mistakes on other strings (unknown answers are allowed).

Under certain conditions on set A, the paper establishes two main results:

1. If P is not equal to NP, then for any polynomial t and constant c, the t-bounded instance complexity ic/sup t/(x: A) of string x to set A is more significant than c times the logarithm of the modulus of x, modulo infinitely often (i.o.).
2. If EXPTIME is not equal to NEXPTIME, then for any polynomial t, there exists another polynomial t' and a constant c such that the t-bounded instance complexity ic/sup t/(x: A) is more significant than K/sup t/'(x) minus c, modulo infinitely often (i.o.).

These results provide insights into the instance complexity of strings about specific sets A under certain complexity assumptions. They demonstrate the intricate relationships between computational complexity classes and the bounded instance complexity of lines, shedding light on the inherent complexity of decision problems in different contexts [8] have lay out that design from movement (SfM) turns out to be computationally NP-hard for most sensible expense capabilities while managing missing information. This outcome uncovers an essential limit in accomplishing ideal arrangements with any SfM calculation. In spite of ongoing promising endeavors to figure worldwide ideal arrangements, the creators show that getting a polynomial time calculation for SfM, except if P=NP, isn't doable.The verification utilizes the strategy of encoding an erratic Boolean equation into a polynomial-sized SfM issue, considering missing information, to such an extent that the SfM issue has an answer with zero expense if and provided that the Boolean recipe is satisfiable. By exhibiting this decrease, the paper lays out an association between SfM issues and the NP-complete issue 3SAT. The ramifications of this decrease is critical: on the off chance that there were an approach to proficiently limit the mistake of the important group of SfM issues in polynomial time, it would suggest the capacity to tackle the NP-complete 3SAT issue in polynomial time. Since 3SAT is a notable NP-complete issue, this would prompt the end that P=NP is a perplexing and basic inquiry in intricacy hypothesis. The evidence depends on results from both the field of construction from movement and intricacy hypothesis, exhibiting the exchange between the two spaces in grasping the computational trouble of SfM issues within the sight of missing information. [9] have presents a clever Fuzzy displaying approach that can successfully address obscure frameworks utilizing a few Fuzzy principles. The proposed Fuzzy model offers a comparable design with Takagi and Sugeno's model (1985) and is as simple to carry out as Sugeno and Yasukawa's (1993). The calculation comprises of two stages: coarse tuning, which includes Fuzzy C-relapse model (FCRM) grouping in view of Fuzzy C-implies (FCM), and tweaking, which uses a slope plummet calculation to definitively change the Fuzzy model's boundaries. This approach is shown through models, showing its adequacy and legitimacy. [10] have presents a numerical device for developing Fuzzy models of frameworks by utilizing Fuzzy ramifications and thinking. The ramifications depict Fuzzy info subspaces, while the results address straight information yield connections. The paper likewise exhibits a framework ID strategy utilizing input-yield information. Two viable utilizations of this strategy to modern cycles are examined: a water-cleaning process and a converter in a steel-production process. These models delineate the adequacy and relevance of the proposed approach in certifiable situations.

[11] have utilizes a fuzzy model to introduce a nonlinear regulator intended for multi-info multi-result (mimo) dynamical frameworks. the fuzzy model is based on an assortment of autoregressive with exogenous information (arx) models consolidated through a fuzzy surmising instrument. the actual regulator is a discrete-time nonlinear decouple. the examination covers both versatile and fixed boundary cases. The paper widely explores the regulator's dependability, showing that the shut circle framework is around the world steady and powerful against unstructured vulnerability. this vulnerability incorporates factors like demonstrating blunders and unsettling influences. the concentrate additionally gives limits on the asymptotic and transient execution of the framework. Certain suppositions are made about the framework and model, including the shortfall of no base stage strong impacts (with the exception of time delay) and a limitation on the size of unstructured vulnerability. the paper incorporates a reproduction guide to outline the demonstrating strategy and the model-based control structure. The creator presents and examinations a vigorous nonlinear regulator for mimo frameworks utilizing a fuzzy model, displaying its strength and execution qualities through hypothetical investigation and reproduction.

[12] have tends to the test of time-series anticipating, especially the absence of strategies that actually catch spatiotemporal reliance in present status of-the-craftsmanship estimating models. The creators propose another organization developing model called the Fuzzy mental perceivability chart (FCVG) to handle this issue. This model believers time series information into coordinated weighted charts by thinking about the Fuzzy association between hubs.

To gauge the comparability between hubs in the FCVG, the creators present a weighted multi-sub chart closeness (WMSS) estimation. They then, at that point, present an

original guaging technique for time series called expectation in view of Fuzzy closeness dissemination (PFSD), proficiently catching spatiotemporal reliance. The PFSD approach includes changing over a period series into an organization utilizing the FCVG and figuring similitude scores between hubs utilizing WMSS. In view of the standardized likeness dispersion, the technique makes expectations for the time series. The article presents broad examinations on various datasets to show the upsides of involving Fuzzy collaboration in time-series anticipating. Furthermore, the creators apply PFSD to gauge a particular time series by foreseeing the development cost record.

In general, the article presents FCVG and PFSD as creative devices for time-series determining, featuring their viability in catching spatiotemporal reliance and further developing expectation precision.

[13] have presents a Programmed Fuzzy Grouping System (AFCF) for picture division, expecting to address the test of physically setting the quantity of bunches in customary grouping calculations that limit a goal capability. The Thickness Pinnacle (DP) grouping technique can find the quantity of assortments naturally yet experiences memory flood when applied to picture division because of a huge likeness lattice for moderate-size pictures.

To handle this issue, the creators propose a triple commitment:

1. They utilize the idea of super pixels to decrease the size of the comparability network, subsequently working on the computational proficiency of the DP calculation effectively.
2. A thickness balance calculation gets a strong choice chart, working with completely programmed bunching with the DP calculation.
3. The structure integrates Fuzzy c-implies grouping in view of earlier entropy to improve picture division results.

The last division result is essentially improved by thinking about spatial adjoining data of the two pixels and enrollment.

Trial results show that the proposed AFCF accomplishes programmed picture division and beats cutting edge calculations concerning division exactness and quality.

[14] have presents another methodology for variety picture division utilizing a super pixel-based quick Fuzzy C-Means (FCM) bunching calculation. Existing FCM calculations for picture division have constraints while managing variety pictures because of high computational intricacy and unfortunate division results brought about by customary adjoining window strategies. To resolve these issues, the proposed calculation embraces a super pixel-based approach. Initial, a multistate morphological inclination remaking activity is applied to get a super pixel picture with precise shapes, which gives versatile and sporadic nearby spatial areas. This further develops variety picture division by saving the normal, neighborhood spatial design. Second, the first variety picture is effectively rearranged, and its histogram is figured by including the quantity of pixels in every district of the super pixel picture. This step works with the execution of FCM with histogram boundaries on the super pixel picture, bringing about the last division. Trial results on manufactured and normal pictures exhibit that the proposed calculation offers better division results and essentially lessens handling time contrasted with cutting edge bunching calculations for variety picture division.

[15] have presents Fuzzy Social Conventional Idea Investigation (FRCA), which plans to mine assortments of Fuzzy idea grids from Fuzzy social setting families. These setting families comprise of Fuzzy conventional settings and Fuzzy relations between objects of various kinds. The FRCA method includes two principal steps: first, changing an underlying Fuzzy social setting family into an assortment of Fuzzy conventional settings, and second, producing a Fuzzy idea grid from each Fuzzy lawful setting utilizing existing strategies. The change of Fuzzy setting families into Fuzzy conventional settings is accomplished utilizing Fuzzy scaling quantifiers, which are explicit Fuzzy quantifiers in light of evaluative semantic articulations. FRCA is important for removing data from multi-social datasets that include dubiousness, and it fills in as an augmentation of both social idea examination and Fuzzy proper idea investigation. The creator's principal commitments incorporate presenting and concentrating on another class of Fuzzy quantifiers called t-scaling quantifiers to extricate Fuzzy ideas from Fuzzy social setting families. A calculation is introduced to produce Fuzzy idea grids from a specific Fuzzy social setting family utilizing a given t-scaling quantifier. An arranged connection is laid out among t-scaling quantifiers, working with the revelation of correspondences among Fuzzy idea grids got from various t-scaling quantifiers. The article additionally examines the expansion of the outcomes from t-scaling quantifiers to the more extensive class of Fuzzy scaling quantifiers, featuring the distinctions between these two kinds of quantifiers.

[16] have discusses recent advancements in fuzzy modelling, demonstrating its efficient application to complex nonlinear systems that are challenging for traditional linear methods. Fuzzy models can handle nonlinear systems and possess other properties that make them attractive for theoretical study and practical industrial applications. The paper provides an overview of different fuzzy modelling approaches, particularly from a control engineering perspective. It emphasizes constructing fuzzy models using numerical data and integrating prior knowledge about the system. Additionally, the paper identifies some open problems in the field.

[17] that the occupation shop booking issue (JSP) is a complicated issue with reasonable importance, as it is trying to address work handling and finishing times because of wild factors like machine deferrals and human elements. To address this, the Fuzzy handling time and consummation time JSP (FJSP) model uses Fuzzy sets for

a more exhaustive booking portrayal. Fuzzy relative entropy empowers assessing the nature of an answer by contrasting genuine qualities and optimal qualities (the due date). Consequently, the multi objective FJSP can be changed into a solitary objective improvement issue and settled utilizing the cross breed versatile differential development (HADE) calculation.

HADE utilizes a transformation methodology in view of DE-current-to-best and adaptively changes its boundaries (CR and F) utilizing typical dispersions. New people are chosen in view of the wellness esteem (FRE) got from a populace of N guardians and youngsters in HADE. Trial results show that HADE beats other cutting edge calculations like insect state streamlining, fake honey bee settlement, and molecule swarm advancement with respect to greatest finishing time, absolute defer time, and all out energy utilization of occupations.

[18] have tell us that the Quadratic Assignment Problem (QAP) is a well-known and challenging problem in facility locations. It is classified as NP-hard, making it difficult to find efficient solutions. In this paper, the authors propose a novel approach to address the QAP by introducing a graph model called the "fuztree." Unlike traditional graph models with fuzzy edges, the fuztree incorporates fuzzy vertices and is closely related to fuzzy inference engines. This unique graph model enables the application of fuzzy inference engines for solving the QAP, potentially providing more effective solutions to the problem.

[19] let us know that the Mobile Sales rep Issue (TSP) is a very much concentrated on NP-hard diagram search issue, with various endeavors to find ideal or semi-ideal arrangements utilizing different methodologies. The Time-Subordinate Mobile Sales rep Issue (TD TSP) broadens the first TSP by considering shifting edge costs, quite greater expenses in rush hour gridlock predicament districts or during busy time periods. This paper presents a more practical methodology called the 3FTD TSP (Triple Fuzzy Time-Subordinate Mobile Sales rep Issue), which fuzzifies the model of the TD TSP. The 3FTD TSP consolidates Fuzzy qualities for the edge costs between hubs, the topographical areas of gridlock locales, and the busy time frames. The goal is to give a down to earth, sensible option in contrast to the crucial TD TSP issue. The Discrete Bacterial Memetic Developmental Calculation is utilized to track down a semi ideal arrangement, as it has demonstrated to be proficient in tackling an extensive variety of NP-difficult issues, including the first TSP and TD TSP. The underlying aftereffects of running the calculation on the lengthy benchmark informational collection from the first TD TSP showed promising and sound results.

[20] have introduces a learning fuzzy production system to tackle a challenging NP-hard problem. This problem involves assigning real-time pre-emptible tasks to various heterogeneous processors while considering placement, resources, communications, and time constraints. The paper demonstrates the system's effectiveness by providing results on the time taken to generate the initial solution and the quantity of solutions identified for well-known problems.

[21] have addresses limiting make range in stream line planning issues utilizing a Fuzzy Cell Hereditary Calculation (FCGA). This issue has functional applications in the assembling of printing and electronic circuit board. The paper presents a summed up number programming (IP) model for this planning issue. To settle the NP-hard IP model, the FCGA is proposed. The calculation's presentation is tried on example issues with laid out ideal arrangements. The FCGA accomplishes similar outcomes to the IP model for minor issues and is viable for additional huge issues.

[22] have investigates existing writing that pre-owned expansion min Fuzzy connection disparities to display shared (P2P) network frameworks, basically zeroing in on absolute download traffic per terminal. Nonetheless, the paper contends that considering the most huge download traffic is more reasonable in unambiguous situations. The paper proposes involving max-min Fuzzy connection imbalances for P2P network frameworks to address this. The principal objective is to decrease network blockage while keeping up with fixed need grades for terminals. The paper presents the idea of a lexicographic least arrangement inside the maximum min Fuzzy connection imbalances structure to accomplish this objective. The creator presents nitty gritty calculations for tackling the lexicographic least arrangement, gives hypothetical verification to their legitimacy, and shows their adequacy through exploratory models.

[23] have tends to basic difficulties in assembling frameworks, explicitly asset booking, position sequencing, and asset designation inside adaptable occupation shop plans. The review centers around the double asset obliged adaptable occupation shop planning (DRCFJSS) issue, taking into account machine breakdowns and functional vulnerabilities. Stochastic situation based techniques are utilized to deal with vulnerabilities, and Fuzzy numbers address questionable interaction times. A vigorous Fuzzy stochastic programming (RFSP) model is proposed to address interruptions like machine breakdowns and functional dangers. The RFSP model joins normal case and most pessimistic scenario execution estimates under potential machine breakdown situations. Because of the intricacy of the DRCFJSS issue, two meta-heuristic calculations, the hereditary calculation (GA) and vibration damping enhancement (VDO) calculation, are applied to huge measured occurrences. The RFSP model is approved through contextual analyses and mathematical trials utilizing CPLEX solver, GA, and VDO calculations for different issue sizes, affirming the viability of the proposed approach, particularly with GA and VDO for medium and huge estimated issues.

[24] have examines the utilization of max-min Fuzzy connection conditions in portraying a three-level media

streaming design. A powerful arrangement idea is acquainted with guarantee the cooperation of all provincial servers in the framework. The paper then analyzes the weighted minimax issue related with this idea. An original methodology is created in the article to accomplish the ideal powerful answer for the proposed Fuzzy connection weighted minimax issue.

[25] have that over the past three decades, significant strides have been made in emphasizing the inclusion of measurement uncertainties in calibration results. The individuals behind various guidance materials deserve recognition for this progress. It's crucial, however, to ensure that these efforts are worthwhile, and a robust campaign is necessary to ensure that all calibration certificates consistently include measurement uncertainties. Without this crucial information, calibration results lack meaningful value.

[26] have that estimation vulnerability is a method for surveying the nature of an estimation, ordinarily by characterizing the reach and spread of measures that would result from a limitless number of reiterations. The Manual for the Declaration of Vulnerability in Estimation (GUM) classifies vulnerabilities in view of measurable assessment or different strategies. It likewise features that a deficient meaning of the "measurand" (what's being estimated) can prompt critical vulnerability in results. This "definitional vulnerability" is especially significant in the Shrewd Matrix, where variables like sign sounds, commotion, and temperature influence estimations, regardless of whether they're not straightforwardly a piece of what's being estimated. These impacting variables can remarkably affect the estimation cycle.

[27] says that vulnerability estimation is vital for information disclosure and information mining. Harsh set hypothesis (RST) is important for overseeing questionable data. While different RST-based strategies have been investigated to quantify framework vulnerability, current estimates need assistance to catch the imprecision in a harsh set successfully. Another vulnerability measure in light of characteristics' detectability capacity is proposed to address this. The hypothetical investigation is upheld by mathematical models, exhibiting that this new strategy conquers the constraints of existing measures as well as adjusts well to human comprehension.

[28] have that a PC-based virtual instrument uses the law of uncertainty propagation, following the "guide to the expression of uncertainty in measurement." The combined output uncertainty in various basic digital signal processing blocks is calculated based on input sample absolute accuracy without considering acquisition board parameters like an adequate number of bits. The validity of this approach is tested through theoretical analysis, numerical simulations, and experimental tests, focusing on a virtual instrument for flicker evaluation. The experimental results align well with the theoretical and numerical findings, validating the proposed method.

[29] that uncertainty is a fundamental aspect of measurements and estimations in the physical world, requiring consideration in modelling data-driven systems. Many modelling languages allow for representing measurement uncertainty regarding specific system attributes, but these features typically need to be integrated into their type systems. Consequently, working with uncertain values and propagating uncertainty in models is usually challenging. This paper suggests enhancing UML and OCL types to include data uncertainty from physical measurements or user estimates within the models, alongside defining operations for these values.

[30] have expects to depict how vulnerability is (or alternately isn't) estimated in legal science and how the proportion of vulnerability can be utilized to pursue better legal choices. From the conventional unique finger impression correlation with the most recent advances in scientific DNA examination, we talk about the benefits and disadvantages of different approaches to detailing legal science results. We highlight past and current discussions and dissect what still needs to be finished in the field to guarantee that the probative worth of criminological science proof is conveyed to legal truth locaters in an experimentally strong, adjusted and straightforward method for permitting them to go with lucid choices.

[31] have an original vulnerability measure for characterization undertakings, named "logit vulnerability," is presented, depending on the logit results of brain organizations. This new measure beats existing vulnerability estimates across different assignments, including recognizing out-of-test cases and distinguishing wrong forecasts. The paper dives into the hypothetical premise of this action and its association with high-thickness locales. Also, the action's application in preparing generative ill-disposed networks is investigated. Two viable purposes of logit-based vulnerability in certifiable situations are proposed, with proof appearance that this vulnerability measure performs especially well.

[32] have presents a refined idea of vulnerability and an overall estimation technique. The differentiation among vulnerability and unsure qualities is made, using vector hypothesis to portray free characteristics of vulnerability. Existing vulnerability modalities are built, and measure models for k periods of vulnerability are proposed in light of target and unsure degrees. These actions are standardized to empower significant examinations. The adequacy of the proposed technique is exhibited by applying it to real climate information, showing its quantitative handling by PCs and featuring its promising application potential.

A. Research Gap Analysis

In general, problem may be solvable, partially solvable and unsolvable. By applying the power of computer science and Information Technology with the help of soft computing techniques including Fuzzy logic, Neural Networks, Genetic Algorithms try to solve the problem up to some extent. In our study; have taken up into consideration the problem of NP hard in order to identify

the Best Goal keepers. Major challenges have faced in order to identify list of features from the set of available features. Even had discussion with subject expert of Foot Ball Game in order to understand the importance of each and every feature and also worked on its sequencing. When particular linguistic term distinguished among low-medium-high or Good-Bad have lot of uncertainty and if you go for more possible values then more uncertainty comes into the picture. So optimization of it is a major challenge that authors have emphasized in it to reduce up to some extent. Identifying the specifications of model with respect to membership function, its ranges, part of fuzzification and de-fuzzification using Mamdani method is also another challenge in order to identify the causes of uncertainty, that we have tried to reduce with the help of optimized rules and discussed in the conclusion section thoroughly.

III. Mathematical Background

We must demonstrate the polynomial many-to-one reduction of the optimal goalkeepers problem in order to demonstrate that it is an NP-Hard problem. The following theorem construct aids in demonstrating that the problem under consideration is NP-hard, as per corollaries 3.1 and 3.2.

Theorem: Consider P1, P2 ,… Pn as the partition set with football players and it has the data with feature f1, f2, … f9 . Then NP-Hard is the identification of the best goalkeepers.

Proof -The partition problem is considered in NP-hard problem [16] and the same is reduced for the identification of the best goalkeeper problem.

Partitions P1, P2 ,… Pn partition, and C represents the edges between partitions, consider the following identifying best goalkeeper problem:

For a player graph G = (V, E) is an undirected unweighted graph,

A partitions { P1, P2,…Pn }of G satisfying P1, P2,…Pn ⊂ V , 8

P1 ∪ P2 ∪…Pn = V,

P1 ∩ P2 ∩….Pn = φ , and

$S = \{\forall\, \mathbb{P}\ \exists\ n \mid \sum_{i=1}^{9} fi \leq 9\}$

Subject to minimize cut

$$\forall \mathbb{P}\left(\forall(Pi, Pj)\exists\left(\{Cut(Pi, Pj) = \sum_{u\in pi, v\in pj} w(u, v)\}\right)\right)$$

where G indicates the graph of players,

V shows the set of vertices,

E represents Edges in graph,

n is the no. of players,

$\mathbb{P}$ is the set of partitions,

S is the set of best goalkeepers,

and $\sum fi$ is the sum of features of the players.

w(u,v) is the edge between vertex from different partition

It demonstrates that if the best possible or optimal value under the specified conditions can be found for the best goalkeeper problem. Then, a subset of partitions P1 of n exists as well, allowing us to obtain balanced partitions with the fewest possible cuts.

Corollary A: Said problem is NP-complete.

Proof: -

The reason this problem falls under the category of non-NP is that polynomial-time allows us to envision or retract a partition and determine whether the condition can actually be satisfied. By lowering the partition issue from NP-complete to NP, we have demonstrated.

Corollary B: The Partition problem is NP-Hard.

Proof: -

Step 1: Corollary 3.1 proves it is NP-complete.

Means we have solution to partitioning problem which is verifiable in polynomial time i.e., non-deterministic.

Step 2: Checking the correct solution depicts it as a decision problem. Means we claim that the guessed partition can be checked for correctness.

Step 3: Indirectly we are claiming that we can reduce the partitioning problem to decision version of this problem.

Step 4: The partition problem is NP-hard since it is easy to reduce the Partition problem to the decision version of this problem. It proves Partitioning is a NP-Hard.

Identifying best goalkeeper problem is polynomial time solvable to the partition problem.

IV. Proposed Methodology: Fuzzy Model for Identifying Uncertainty Causes

This section focuses on identifying Best Goal Keepers through fuzzification and membership functions. This model has nine features including ball_control, vision, positioning, kicking, diving, long_passing, reflexes, penalties, overall_rating. Its corresponding experimentation details, result analysis have been incorporated thoroughly.

Table 1: The list of parameters and the values

Parameter Name	Possible Value1	Possible Value2	Possible Value3
Vision	poor	good	---
Ball control	low	moderate	high
Overall Rating	low	moderate	high
Kicking	Poor	moderate	Strong
Diving	Low	Moderate	High
Reflexes	Bad	Good	---
Positioning	Poor	Moderate	Strong
Long	No	Yes	---

passing Penalties	No	Yes	---

Here, must set up an experiment to identify the best goalkeepers based on their profile. Table 1 parameters have been used as input for the experiment.

Here in this fuzzy model, we have 9 input variables along with their possible values, as shown in the Table 1 and one output variable to check the goalkeeper quality along with possible values as "good" or "bad". The details related to the developed fuzzy model has shown in the Table 2:

Table 2: Fuzzy model specifications

Specification	Value
Number of inputs	9
Each input values	2-3
Number of outputs	1
Values excepted for output	2
Membership function type	Triangular
Input variable range	[0-1]
Output variable range	[0-1]
FIS Type	Mamdani

Now further more will derive the theory of membership function: Authoritatively, an enlistment capacity for a fuzzy set A on the universe of discourse X is portrayed as $\mu A: X \rightarrow [0, 1]$, where each part of X is planned to a worth some place in the scope of 0 and 1. This worth, called membership value or degree of membership enrollment, gauges the grade of enlistment of the part in X to the fuzzy set A.

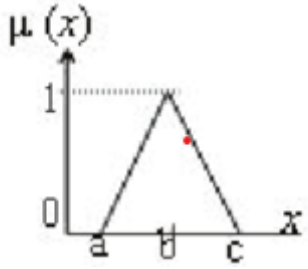


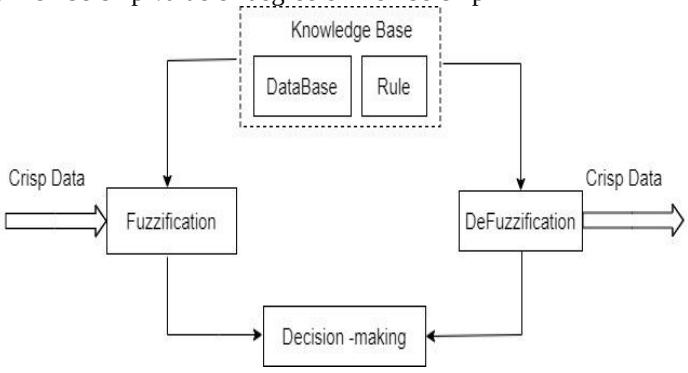
Figure 2: Triangular membership Function

Now will introduce Fuzzy Inference System (FIS) to setup the experiment for this model and degree of membership (Figure 2) is supposed to be plan as per the need of every feature.

FIS is very important toolkit of fuzzy logic framework in order to setup the experiment. This helps to define the membership functions by adding the rule base by utilizing the existing connectors OR, AND and NOT. This FIS system helps to automate fuzzification and de-fuzzification process along with membership function.

A. Useful Blocks of FIS:

Figure 3 gives utilitarian block outline, which will assist with grasping the development of said system and which uses Mamdani FIS −



Rule Base − It contains Fuzzy On the off chance that guidelines.
Data set − It characterizes the participation elements of Fuzzy sets utilized in Fuzzy standards.
Independent direction − It performs procedure on rules.
Fuzzification − It changes over the fresh amounts into Fuzzy amounts.
De-Fuzzification − It changes over the Fuzzy amounts into fresh amounts or result.

Figure 3: Block diagram of FIS

Now will introduce block diagram of Mamdani Fuzzy Interface System.

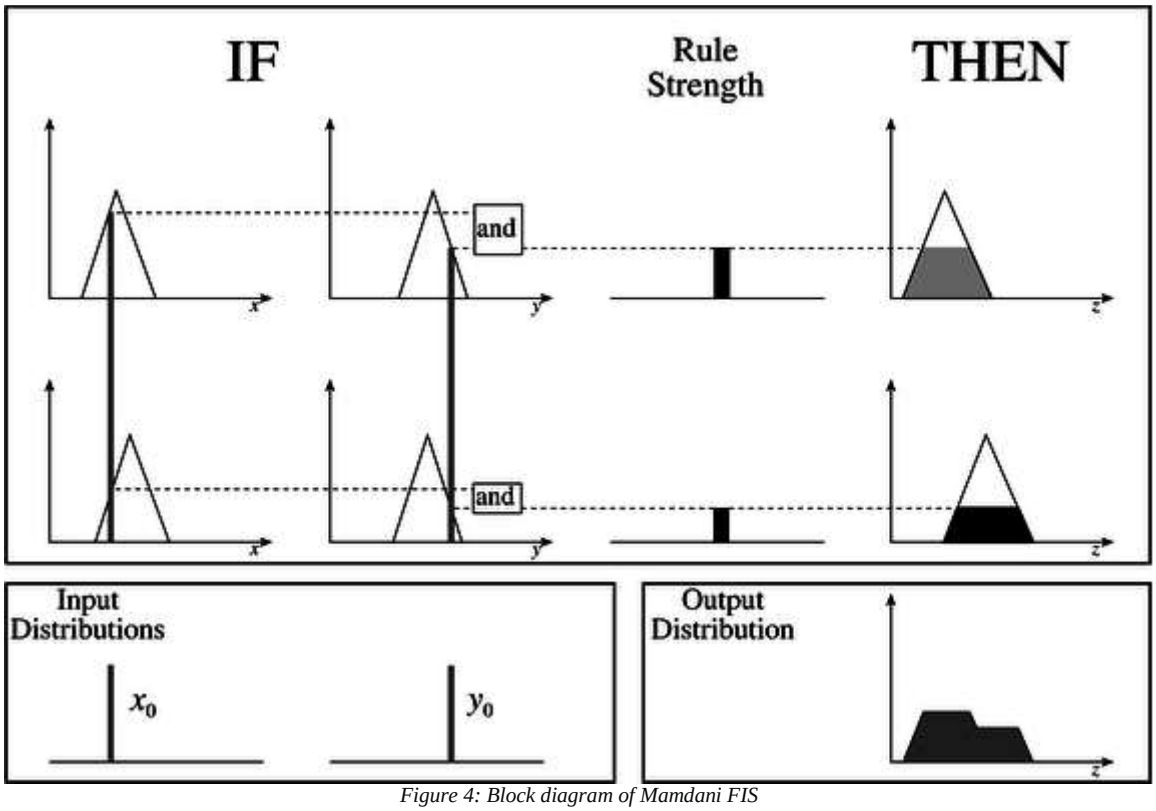


Figure 4: Block diagram of Mamdani FIS

B. Result Analysis

In this experiment, out of 9 inputs, 5 inputs had 3 possible values, and 4 inputs had 2 possible values. Hence this experiment generates a total of 3888 rules. These rules are tested along with the possible two output values defined for selecting goalkeepers as "good" or "bad". While testing the rules-based system, some uncertainty has been observed, to overcome this uncertainty, the rules have been optimized by observing the final output value. The optimized rule-base has a total of 45 rules. The output values for this rule-base have been ranges from 0.281 to 0.828. Table 3 gives typical sample of optimized rules.

Table 3: Typical set of optimized rules

Rule Number	Rule
1	(Vision==poor) & (ball_control==low) & (overall_rating==low) & (kicking==poor) & (diving==low) & (reflexes==bad) & (positioning==poor) & (long_passing==no) & (penalties==no) => (GoalKeeper=bad)
11	(Vision==good) & (ball_control==high) & (overall_rating==modrate) & (kicking==strong) & (diving==high) & (reflexes==bad) & (positioning==strong) & (long_passing==yes) & (penalties==yes) => (GoalKeeper=bad)
24	(Vision==good) & (ball_control==high) & (overall_rating==low) & (kicking==strong) & (diving==high) & (reflexes==good) & (positioning==strong) & (long_passing==yes) & (penalties==no) => (GoalKeeper=good)
39	(Vision==good) & (ball_control==high) & (overall_rating==high) & (kicking==strong) & (diving==modrate) & (reflexes==good) & (positioning==poor) & (long_passing==no) & (penalties==no) => (GoalKeeper=good)
45	(Vision==good) & (ball_control==high) & (overall_rating==modrate) & (kicking==strong) & (diving==modrate) & (reflexes==good) & (positioning==strong) & (long_passing==yes) & (penalties==yes) => (GoalKeeper=good)

The 45 optimized rules generate output values ranging from 0.281 (minimum) to 0.828 (Maximum).

The Table 4 shows the clustering of rules which generates the nearby values of output.

Table 4: Clustering of generated output values

Cluster No	Rule Number	Total Number of rules	Generated output value
1	3,4,5,6, 13,14,15,17	8	0.762
2	9,10,23,24,25,27,28	7	0.647
3	30, 36,37,38,39,10,41,42,43	9	0.828
4	1,2,7,8,11,12,26	7	0.494
5	18,19,20,21,29	5	0.391
6	31,32,33,34,35	5	0.281

Table 4 is being based on 45 optimized rules ranging from 1-45 constitutes of six different clusters. Each cluster consists of rules 8,7,9,7,5,5 respectively along with its corresponding generated output value. E.g., output value is 0.762, its corresponding 8 rules which will get same result incorporated into the cluster 1, likewise other results have been obtained.

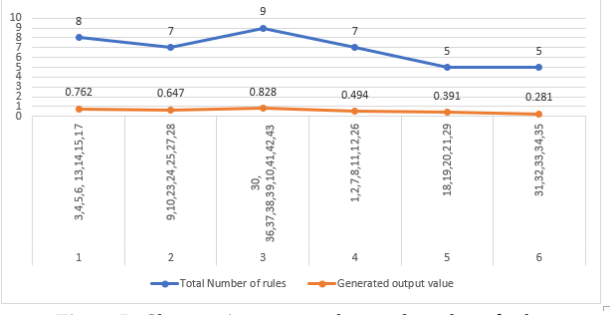


Figure 5: Cluster-wise output values and number of rules

Figure 5 shows the cluster-wise distribution of output values and the rules that fall in that cluster. Fuzzy logic is a way to deal with processing in view of "levels of truth" as opposed to the standard thing "valid or misleading" rationale. It manages thinking that is estimated as opposed to exact to tackle issues such that more looks like human rationale, thus information base questioning cycle by the two-esteemed acknowledgment of Boolean polynomial math is not satisfactory.

V. Conclusions and Future Scope

On the basis of analysis so far, major highlight concern is with respect to Uncertainty Measures and rule-based optimization. The uncertainty in fuzzy rule-based has occurred due to the following reasons:

Uncertainty due to the possible values used in rule-based to input the values of the various parameter like ball_controll values are high, low, moderate or reflexes values are good, bad. Such values do not have definite prescribed numeric values; due to this, the final numeric output is uncertain. The uncertainty is also caused due to the consequence that happened in the result, as there were overlaps in the output of different rules. The membership function spread will yield uncertainty. When input parameters like kicking, which indicate the kick ability of a player, have three possible values: low, moderate and strong. When this parameter has converted in the triangular member function. It has some parameter value distribution near the boundaries of the actual value sets representing low, moderate and strong. It may have uncertainty for such distributed values if that is wrongly added in a different set.

The rule-based complexity is also one of the causes of uncertainty. The proposed rule based of this model has a total of 3888 possible rules. This high number is increasing the complexity, which causes uncertainty in the implementation of this rule base. To reduce the complexity and the uncertainty, the rule base has been optimized, and a total of 45 rules have been adopted to finalize the rule base. Here, the rule-based has optimize to 88% which minimize the uncertainty.

In near future, researcher can measure the uncertainty causes by setting up the experiment by using trapezoidal membership function, sigmoidal etc. Even though they can setup the experiment in such a way that; comparative analysis could be possible by using Mamdani Method and Takagi Sugeno.

Author Contributions: Conceptualization: P.S Metkewar, Nilkanth Mukunde Deshpande. Data curation: [1]P S Metkewar, Nilkanth Mukund Deshpande, Shed Irfan Yaqoob, formal analysis: Nilkanth Mukund Deshpande, Syed Irfan Yaqoob; Investigation, P S Metkewar and Nilkanth Mukund Deshpande; Methodology: P S Metkewar and Nilkanth Mukund Deshpande and Syed Irfan Yaqoob; Writing—original draft: P S Metkewar; Review and editing: All authors have read and agreed to the published version of the manuscript.

E-mail:author's email

"Funding: Any other institution did not support this research.
Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability **Statement:** The data and experimental setup details used in this study are available under request.
Acknowledgments: The authors would like to thank the editors and reviewers for their constructive comments, which led to improvement in the presentation of the manuscript.
Conflicts of Interest: The authors declare no conflict of interest."

References

[1]: B. Chen and G. Quan, "NP-Hard Problems of Learning from Examples," *2008 Fifth International Conference on Fuzzy Systems and Knowledge Discovery*, Jinan, China, 2008, pp. 182-186, doi: 10.1109/FSKD.2008.406.
[2]: J. O'Rourke and K. Supowit, "Some NP-hard polygon decomposition problems," in *IEEE Transactions on Information Theory*, vol. 29, no. 2, pp. 181-190, March 1983, doi: 10.1109/TIT.1983.1056648.
[3]: T. T. Nguyen, C. Soussen, J. Idier and E. -H. Djermoune, "NP-hardness of ℓ0 minimization problems: revision and extension to the non-negative setting," *2019 13th International conference on Sampling Theory and Applications (SampTA)*, Bordeaux, France, 2019, pp. 1-4, doi: 10.1109/SampTA45681.2019.9030937.
[4]: A. Elorza, L. Hernando and J. A. Lozano, "Transitions from P to NP-hardness: the case of the Linear Ordering Problem," *2022 IEEE Congress on Evolutionary Computation (CEC)*, Padua, Italy, 2022, pp. 1-8, doi: 10.1109/CEC55065.2022.9870392.
[5]: D. Newth, M. Kirley and D. G. Green, "An investigation of the use of local search in NP-hard problems," *2000 26th Annual Conference of the IEEE Industrial Electronics Society. IECON 2000. 2000 IEEE International Conference on Industrial Electronics, Control and Instrumentation. 21st Century Technologies*, Nagoya, Japan, 2000, pp. 2710-2715 vol.4, doi: 10.1109/IECON.2000.972426.
[6]: E. A. Abdelhafiez and F. A. Alturki, "A new optimization algorithm for solving NP-hard problems," *2010 International Conference on Mechanical and Electrical Technology*, Singapore, 2010, pp. 59-63, doi: 10.1109/ICMET.2010.5598491.
[7]: P. Orponen, "On the instance complexity of NP-hard problems," Proceedings Fifth Annual Structure in Complexity Theory Conference, Barcelona, Spain, 1990, pp. 20-27, doi: 10.1109/SCT.1990.113951.
[8]: D. Nister, F. Kahl and H. Stewenius, "Structure from Motion with Missing Data is NP-Hard," 2007 IEEE 11th International Conference on Computer Vision, Rio de Janeiro, Brazil, 2007, pp. 1-7, doi: 10.1109/ICCV.2007.4409095.
[9]: Euntai Kim, Minkee Park, Seunghwan Ji and Mignon Park, "A new approach to fuzzy modeling," in *IEEE Transactions on Fuzzy Systems*, vol. 5, no. 3, pp. 328-337, Aug. 1997, doi: 10.1109/91.618271.
[10]: T. Takagi and M. Sugeno, "Fuzzy identification of systems and its applications to modeling and control," in IEEE Transactions on Systems, Man, and Cybernetics, vol. SMC-15, no. 1, pp. 116-132, Jan.-Feb. 1985, doi: 10.1109/TSMC.1985.6313399.
[11]: T. A. Johansen, "Fuzzy model based control: stability, robustness, and performance issues," in IEEE Transactions on Fuzzy Systems, vol. 2, no. 3, pp. 221-234, Aug. 1994, doi: 10.1109/91.298450.
[12]: Y. Hu and F. Xiao, "Time-Series Forecasting Based on Fuzzy Cognitive Visibility Graph and Weighted Multisubgraph Similarity," in IEEE Transactions on Fuzzy Systems, vol. 31, no. 4, pp. 1281-1293, April 2023, doi: 10.1109/TFUZZ.2022.3198177.
[13]: T. Lei, P. Liu, X. Jia, X. Zhang, H. Meng and A. K. Nandi, "Automatic Fuzzy Clustering Framework for Image Segmentation," in IEEE Transactions on Fuzzy Systems, vol. 28, no. 9, pp. 2078-2092, Sept. 2020, doi: 10.1109/TFUZZ.2019.2930030.
[14]: T. Lei, X. Jia, Y. Zhang, S. Liu, H. Meng and A. K. Nandi, "Superpixel-Based Fast Fuzzy C-Means Clustering for Color Image Segmentation," in IEEE Transactions on Fuzzy Systems, vol. 27, no. 9, pp. 1753-1766, Sept. 2019, doi: 10.1109/TFUZZ.2018.2889018.
[15]: S. Boffa, "Extracting Concepts From Fuzzy Relational Context Families," in IEEE Transactions on Fuzzy Systems, vol. 31, no. 4, pp. 1202-1213, April 2023, doi: 10.1109/TFUZZ.2022.3197826.
[16]: R. Babuska, "Fuzzy modeling - a control engineering perspective," Proceedings of 1995 IEEE International Conference on Fuzzy Systems., Yokohama, Japan, 1995, pp. 1897-1902 vol.4, doi: 10.1109/FUZZY.1995.409939.
[17]: G. -G. Wang, D. Gao and W. Pedrycz, "Solving Multiobjective Fuzzy Job-Shop Scheduling Problem by a Hybrid Adaptive Differential Evolution Algorithm," in IEEE Transactions on Industrial Informatics, vol. 18, no. 12, pp. 8519-8528, Dec. 2022, doi: 10.1109/TII.2022.3165636.
[18]: M. R. Gholamian and S. M. T. F. Ghomi, "A new fuzzy graph model for QAP problem," 2004 IEEE International Engineering Management Conference (IEEE Cat. No.04CH37574), Singapore, 2004, pp. 1333-1337 Vol.3, doi: 10.1109/IEMC.2004.1408911.
[19]: L. T. Koczy, P. Foldesi, B. Tuu-Szabo and R. Almahasneh, "Modeling of Fuzzy Rule-base Algorithm for the Time Dependent Traveling Salesman Problem," 2019 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), New Orleans, LA, USA, 2019, pp. 1-6, doi: 10.1109/FUZZ-IEEE.2019.8858853.
[20]: J. Orozco, R. Cayssials, J. Santos and E. Ferro, "Design of a learning fuzzy production system to solve an NP-hard real-time assignment problem," Proceedings of the Eighth Euromicro Workshop on Real-Time Systems, L'Aquila, Italy, 1996, pp. 146-150, doi: 10.1109/EMWRTS.1996.557845.
[21]: A. N. Shirazi, M. Steinhaus, M. Agostinelli and M. Sodhi, "Fuzzy cell genetic algorithm approach for flexible flow-line scheduling model," 2016 IEEE Symposium Series on Computational Intelligence (SSCI), Athens, Greece, 2016, pp. 1-7, doi: 10.1109/SSCI.2016.7850082.
[22]: This work was supported in part by the National Natural Science Foundation of China under Grant 61877014, and in part by the Education Department of Guangdong Province under Grant 2019KZDXM013, Grant 2016KTSCX085, and Grant ZD201802.
[23]: P. Soofi, M. Yazdani, M. Amiri and M. A. Adibi, "Robust Fuzzy-Stochastic Programming Model and Meta-Heuristic Algorithms for Dual-Resource Constrained Flexible Job-Shop Scheduling Problem Under Machine Breakdown," in IEEE Access, vol. 9, pp. 155740-155762, 2021, doi: 10.1109/ACCESS.2021.3126820.
[24]: P. Soofi, M. Yazdani, M. Amiri and M. A. Adibi, "Robust Fuzzy-Stochastic Programming Model and Meta-Heuristic Algorithms for Dual-Resource Constrained Flexible Job-Shop Scheduling Problem Under Machine Breakdown," in IEEE Access, vol. 9, pp. 155740-155762, 2021, doi: 10.1109/ACCESS.2021.3126820.
[25]: L. B. Cronin, "The importance of uncertainty of measurement," IEE Workshop on Uncertainties Workshop: Electrical Measurements (Ref. No. 1999/197), Glasgow, UK, 1999, pp. 3/1-3/5, doi: 10.1049/ic:19990878.
[26]: W. Dickerson et al., "Smart grid measurement uncertainty: Definitional and influence quantity considerations," 2018 First International Colloquium on Smart Grid Metrology (SmaGriMet), Split, Croatia, 2018, pp. 1-5, doi: 10.23919/SMAGRIMET.2018.8369831.
[27]: S. Teng, D. Zhang, L. Cui, J. Sun and Z. Li, "A new uncertainty measure of rough sets," 2009 IEEE International Conference on Robotics and Biomimetics (ROBIO), Guilin, China, 2009, pp. 1189-1193, doi: 10.1109/ROBIO.2009.5420845.
[28]: S. Caldara, S. Nuccio and C. Spataro, "Measurement uncertainty estimation of a virtual instrument," Proceedings of the 17th IEEE Instrumentation and Measurement Technology Conference [Cat. No. 00CH37066], Baltimore, MD, USA, 2000, pp. 1506-1511 vol.3, doi: 10.1109/IMTC.2000.848724.
[29]: A. Vallecillo, C. Morcillo and P. Orue, "Expressing Measurement Uncertainty in Software Models," 2016 10th International Conference on

the Quality of Information and Communications Technology (QUATIC), Lisbon, Portugal, 2016, pp. 15-24, doi: 10.1109/QUATIC.2016.013.
[30]: J. Vuille and F. Taroni, "Measuring Uncertainty in Forensic Science," in IEEE Instrumentation & Measurement Magazine, vol. 24, no. 1, pp. 5-9, February 2021, doi: 10.1109/MIM.2021.9345602.
[31]: H. Wu and D. Klabjan, "Logit-based Uncertainty Measure in Classification," 2021 IEEE International Conference on Big Data (Big Data), Orlando, FL, USA, 2021, pp. 948-956, doi: 10.1109/BigData52589.2021.9672066.
[32]: L. Hong and Y. Zhang, "Measure of k phases uncertainty," 2017 12th International Conference on Intelligent Systems and Knowledge Engineering (ISKE), Nanjing, China, 2017, pp. 1-4, doi: 10.1109/ISKE.2017.8258722.
[33]: Anuja Bokhare and P S Metkewar, “Identifying Best Goalkeepers problem is a NP-Hard?“, World Conference on Information Systems for Business Management (ISBM) 2023 Thailand, (accepted in Springer SIST proceedings)

Dr P S Metkewar has awarded with "Parbhani Ratna" award for his excellence in academics in 1996. He stood rank first in M.Sc. (computer science) in 1997. He received his Ph.D. degree from SRT University, Nanded in computer science under the faculty of science in Aug 2005. He has 24 years of experience in the field of teaching, R & D and industry. He has worked in the IDRBT R&D centre in the capacity of Research Officer for three years. He has also worked in Zensar Technologies Limited as an Technical Architect position for four years. His specialization is in OOAD, Information Systems, Neural networks, Machine learning, Data analytics, Graph Theory, Image Analysis and Fuzzy Logic. He was a research mentor of Symbiosis International University under the Faculty of Computer Studies. He is also mentoring students for writing research papers, handling their projects as well. He is a CSI life member. He was a member of the BOS Sub-committee, Academic council, BOS and Anti-Ragging committee in SIU, Pune. He had Industry - Academia collaboration with Zensar Technologies Ltd. and K.L. University, Vijayawada (AP). He has presented and published 101 research papers in International Journal, National Journal and IEEE and Springer proceedings and also 04 books in his account. He is a research guide of Symbiosis International (Deemed University), Pune. He worked as Programme chair and steering committee member for EICTSDT 2018 International Conference @SICSR Pune.

Dr. Nilkanth Deshpande is currently working as academician and researcher in Symbiosis Institute of Technology, Pune. He completed his Ph.D from Symbiosis International (Deemed University), Pune. He completed his masters in Government Engineering college, Aurangabad, Maharashtra, India and Bachelors in Engineering fro m SPPU, Pune, Maharashtra, India. He published papers and patents in reputed journals. His area of interest include medical imaging, signal and image processing, machine and deep learning, eXplainable AI, GenAI, and Vision transformers.

Dr. Syed Yaqoob