Leveraging Neural Networks and Ensemble Methods for Predicting NIRF Rankings

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Abstract:

This study aims to analyze the factors influencing the National Institute Ranking Framework (NIRF) for colleges in India. In collaboration with the Ministry of Education, NIRF assesses and ranks top colleges in the country based on specific parameters, including Teaching Learning and Resources, Research and Professional Resources, Graduation Outcomes, Outreach and Inclusivity, and Perception. Each parameter holds a predefined weightage, collectively contributing to a total score of over 100 marks. These rankings serve as a crucial decision-making tool for students in selecting the best colleges and have far-reaching implications for employment, the economy, and the nation's sustainable development.In this research, we conducted an in-depth analysis of NIRF college rankings for 2020 to 2022, utilizing secondary data sourced from educational institutions and the official NIRF ranking websites. The collected data was organized into tabular formats, and we applied a range of machine learning algorithms, including Convolutional Neural Network (CNN), linear regression, Multi-Layer Perceptron (MLP), Bagging, and boosting methods. These algorithms were assessed using various performance metrics, such as MAE, RMSE, MSE,and MAPE, to provide valuable insights and predictions.Through our analysis of the NIRF parameters, we have developed a model capable of making score and rank predictions in advance. This model offers educational institutions a valuable tool to comprehensively understand the evolution of the higher education system in India. By pinpointing areas that require improvement, colleges and universities can proactively work towards enhancing their rankings, ultimately contributing to the advancement of the education sector in the nation. Our findings shed light on the critical factors influencing college rankings and provide a pathway for continuous improvement in the education landscape.

Keywords: NIRF, Perception, Sustainable Development, CNN, Bagging and Boosting, ANN

1.1.Introduction:

The National Institutional Ranking Framework (NIRF) [1] is a system for ranking higher education institutions in India developed by the Ministry of Human Resource Development. Our analysis reveals a bias in the NIRF rankings towards larger and older colleges. This bias stems from the significant influence of factors such as faculty-student ratio, research performance, publication metrics, and graduation rates on the overall score [2]. This finding is corroborated through a correlation analysis examining the relationship between age and the scores acquired from NIRF and NAAC assessments.The NIRF ranking process involves a three-stage approach. First, institutions provide information, which is then validated for consistency. Second, the criteria are consistently applied. Third, a combination of quantitative and qualitative analyses is used for ranking [3]. This approach includes statistical analysis of quantitative data and qualitative methods like stakeholder feedback and expert opinions. The NIRF ranking system, initiated in 2016, has become a significant benchmark for Indian higher education institutions [4], with its foundation based on recommendations from the National Institutional Ranking Framework Committee established by the Ministry of Human Resource Development in 2014.

The NIRF ranking technique is now used to analyze and rank India's higher education institutions, helping colleges identify strengths and weaknesses [5].The authors employ ABCD to identify the NIRF system's key components and examine its main flaws [6]. The framework was developed through a consultation process and covers several parameters and sub-parameters. To compare themselves to their peers and make informed judgments, students, parents, institutions, and universities use the rankings [7, 8]. The framework has received criticism, but it has also improved transparency and accountability in India's higher education system. The objective of this research is to deliver an accurate and transparent indicator of the caliber of the nation's higher education institutions.

1.2.Review of Literature

The studies show that the quality of publications is just as important as the number of publications in achieving a better score in research publication metrics [9]. The proposed minimum percentage of quality publications for each category of faculty is as follows: 50% in Scopus and 50% in Web of Sciences for Professors, 25% in Scopus [10], 50% in Web of Sciences, and 25% in Google Scholar for Associate Professors, and 50% in Web of Science and 50% in Google Scholar for Assistant Professors [11]. The study found that older institutions generated more publications than newer ones. It focused on active scientists on ResearchGate and used an online survey method[12].To evaluate the excellence of tertiary education establishments in Australia and New Zealand,the article emphasizes the need for a nuanced and critical approach to rankings [13]. In 2015, the President of India emphasized the importance of improving university rankings and expressed disbelief that no Indian university met the criteria for the top 200 global rankings during the BRICS Summit [14]. The article suggests that we need to critically examine ranking methodologies, data sources, and normalization procedures, to identify how these rankings are constructed and what values and interests they represent [15].

A multi-modeling strategy is employed to assess the credibility of the ranking's individual university, as well as the relative performance of countries or broader geographical regions [16]. The authors argue that while university rankings can be useful, they are subject to several technical and conceptual challenges that must be carefully addressed to ensure their reliability and validity [17]. Another study critically examine two well-known ranking systems, the THES, global university ratings, and the Shanghai Jiao Tong instructional ranking of global Universities, assessing the criteria used by every and arguing that the Jiao Tong system is a higher indicator of university excellence [18].By providing universities with clear feedback on their performance, rankings can help to incentivize improvements in areas such as teaching quality, research output, and internationalization [19]. By examining an expanded set of indicators, the research seeks to provide a more comprehensive understanding of the factors that drive university

rankings [20].A research study found that Indian accreditation and ranking bodies tend to be more lenient in their evaluations, resulting in higher scores, while international accreditation and ranking processes adhere to stricter criteria [21].

A study suggests that an accreditation model can rank HEIs across various educational verticals by expanding parameters [22]. This ranking system would prioritize core development areas to provide dependable data for shaping education policiesbased on bibliometric indicators [23]. Another study proposes that universities are evaluated using comparable performance indicators and ranked accordingly, indicating their relative position compared to other universities. [24].An analysis shows that participating institutions have made significant efforts to improve their performance and increase the number of publications, citations, and highly cited publications[25]. A Study suggested that to expand the national ranking system by including additional parameters such as the development of life skills and personality, excellence in sports, and competitive examinations [26]. India has been working towards improving its university rankings since the acceptance of globalization.Building a world-class university takes time and cannot be achieved overnight [27].A paper explored the idea of establishing a national ranking system for Indian universities using the IFQ2A index [28]. Therefore, the paper suggests that it would be meaningful to initially focus on the research contributions of higher educational institutions (HEIs) in India when creating a national ranking system [29]. These practices reflect the credibility and quality of life at a college and are still a scientific approach to addressing social issues. Best practices are agents of change for educational institutions [30] and society. An investigation delved into the feasibility of incorporating the Research and Professional Practices dimension within the NIRF ranking system. This was achieved by scrutinizing the research productivity of scholars hailing from five central Indian universities over the preceding three-year period. [31]. The researchers used databases like the Web of Science, SCOPUS, and the Indian Citation Index to gather data.Additionally, the study aims to examine the correlation between the three-year RP score, the five-year RP score, and the weighted score of institutions [32]. The paper also intends to determine the Spearman rank correlation between RP rank and overall rank based on the scores

of all parameters [33]. Research aimed to study and analyze the placement records of top-ranked institutions in India, and to draw meaningful conclusions about their success rates and the salaries offered to their graduates [34]. One of the main concerns is that rankings can become the driving force for higher education institutions (HEIs), causing them to focus on achieving higher rankings rather than improving the quality of education they provide [35]. A survey was conducted of quality managers at German higher education institutions to determine how effective they perceive their quality assurance approaches to be [36]. The study's results were verified using three prominent global university rankings. Inconsistencies were observed in the parameters and validation methods employed by these ranking tables [37]. An article critically examines significant matters concerning these two highly prominent trends and their impact on the progress of tertiary education within developing nations [38]. A shift has taken place in higher education systems worldwide, with a focus on the top 100 institutions, even though there are over 16,000 higher education establishments globally. [39]. This would help to address the high weightage indicators in global university ranking systems, leading to improvements in the overall ranking of Indian universities on a global scale [40].

1.3. Methodology

In this work, we utilized machine learning to analyze and forecast the NIRF rankings of colleges. For an appropriate result, every technology used to analyze and anticipate must follow a set of processes. It is as simple as "garbage in, garbage out" in machine learning.

1.3.1 Data Collection

The collected data can be examined and evaluated to gather insights and form judgments. So here we have collected the ranking data from the NIRF website, where every year's rankings of colleges are uploaded. In the next step, from the reference of the ranks in the website, we collected the input parameters data from the pictograms of the college, and in detail, for sub-parameters input, we visited the

college websites individually and downloaded the data. In combination, we have collected data from over 100 colleges in 2021 and 2022. We have cleaned the data and removed the colleges that don't have full details on the websites.

1.3.2 Machine Learning Models

The iterative data modeling process involves collaboration between business analysts, developers, and database administrators. There are 46 columns and 119 rows in our dataset. This data comprises college data for the years 2020, 2021, and 2022 based on the NIRF rankings. We employed various machine learning methods in this data modeling, including linear regression, neural networks, bagging, boosting, and MLP. Machine learning algorithms are applied to every parameter and sub-parameter to determine the factors influencing the scores; however, the functions in the NIRF-defined methodology are unmentioned and uncrackable.

Linear Regression:

The dependent variable can be represented by a linear combination of the independent variables, assuming a linear relationship exists between the variables.

Multiple linear regression extends the concept to cases with multiple independent variables.

$$Y = b_0X_o + b_1X_1 + b_2X_2 + \cdots b_nX_n \quad (1)$$

Random Forest:

This ensemble learning technique belongs to the bagging subcategory or bootstrap aggregating. Random Forest builds a collection of decision trees using a random selection of training data and features. This randomization aids in improving the model's generalizability and decreasing overfitting.

Bagging:

This technique pertains to ensemble learning, wherein predictions from numerous models, each trained on distinct subsets of training data, are merged. The underlying concept of bagging aims to mitigate variance

and enhance generalization by averaging predictions derived from multiple models. Based on its learned parameters and a fresh input instance, each Model m makes a prediction.

Boosting:

Unlike bagging, boosting focuses on sequentially improving the performance of the models by giving more weight to instances that were misclassified in previous iterations.Here is the general idea of boosting with the mathematical equations involved:

Data Weight Initialization: Each instance in the training dataset is assigned an initial weight, denoted as w_i, where i ranges from 1 to N, representing the number of instances in the dataset. Initially, all instances have equal weights, soI /N.

Model Training Iterations: Boosting proceeds through a series of iterations, where weak learners are trained sequentially. In each iteration t, a weak learner denoted as$Model_t$, is trained one training dataset with instance weights w_i.

Weight Update and Instance Importance: After training$Model_t$, the weights of the instances are updated to give more importance to the misclassified instances. The weight update formula is as follows:

For misclassified instance I in iteration t:

$$w_i(t+1) = w_i(t) * e^{\alpha\_t} \quad (2)$$

For correctly classified instance i in iteration t:

$$w_i(t+1) = w_i * e^{-\alpha\_t} \quad (3)$$

Here, α_t is the weight adjustment factor, depending on the performance of$Model_t$. It is calculated based on the error rate (ε_t) of Model_t using the following equation:

$$\alpha_t = 0.5 \times \text{Ln}\left(\frac{1-\epsilon_t}{\epsilon_t}\right) \quad (4)$$

In the weight update formula, greater weight is assigned to instances that are classified incorrectly, while lower weight is allocated to instances that are classified correctly. Model Weight Calculation: After

updating the instance weights, the weight of$Model_t$ is calculated based on its performance. The model weight, denoted as βt, is determined as follows:

$$\beta_t = \text{Ln}\left(\frac{1-\epsilon_t}{\epsilon_t}\right) \quad (5)$$

The model weight βt represents the contribution of$Model_t$ to the final prediction.The ultimate prediction is calculated by amalgamating the forecasts of all the weak learners. The prediction of each weak learner is multiplied by its corresponding model weight, βt, and subsequently summed up:

$$Prediction = \Sigma(\beta_t * Predictiont) \quad (6)$$

Here, $Predictiont$is the prediction made by$Model_t$.

By iteratively training weak learners and adjusting instance weights, boosting focuses on difficult instances and learns to classify them correctly. Boosting algorithms such as AdaBoost (Adaptive Boosting) and Gradient Boosting are popular variations of boosting that differ in their specific implementation details.

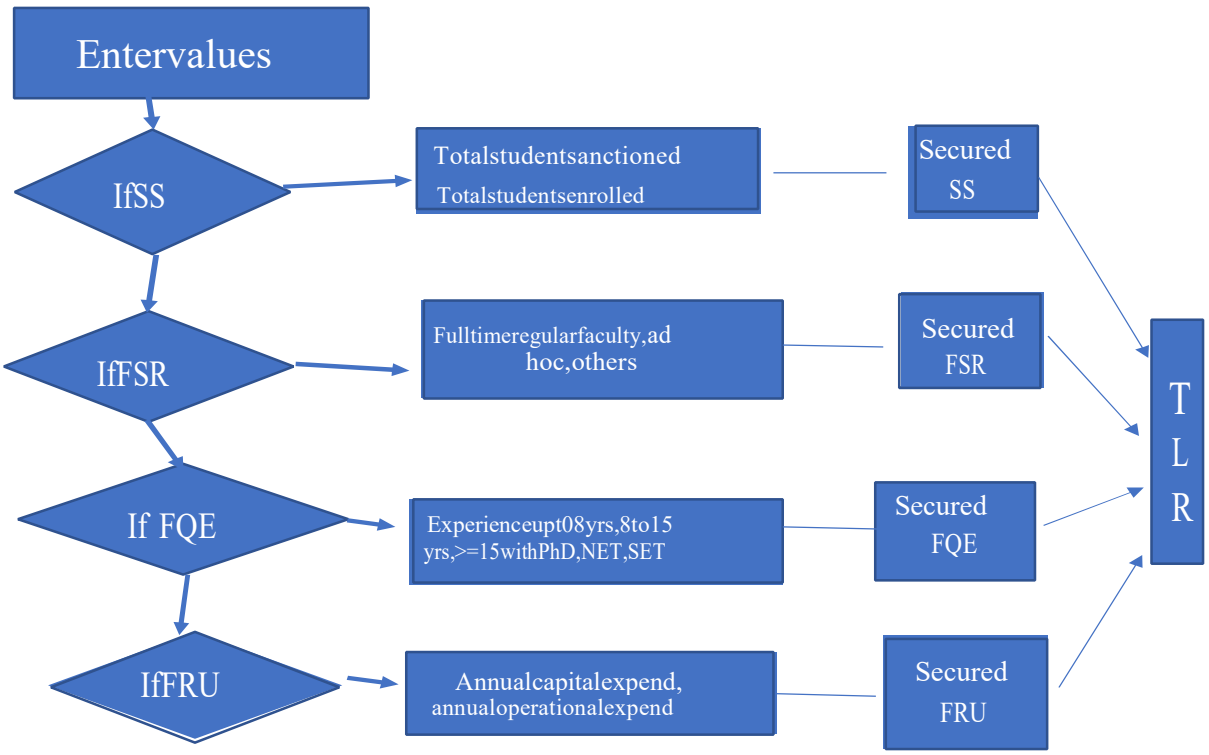

FIGURE 1.1: Model design of TLR parameter as a sample

Figure 1.1 represents the TLR parameter model as a sample. This design follows all the other parameters.

1.4. Results and Discussion

In this research, our analysis of the National Institute Ranking Framework (NIRF) for colleges in India reveals a multifaceted impact on higher education and the nation as a whole. NIRF rankings are not merely numbers; they serve as guiding stars for students navigating the complex landscape of higher education. The rankings influence pivotal decisions, ensuring that students are equipped with essential information to choose the colleges that align with their aspirations and goals. Beyond individual choices, these rankings have profound societal implications. A higher NIRF ranking for a college significantly enhances the employability of its graduates, which, in turn, contributes to the economic growth and sustainable development of the nation.

Our study takes a data-driven approach, employing advanced machine learning algorithms and performance metrics to provide robust insights into the factors that shape the NIRF rankings. By developing a predictive model that can anticipate college scores and rankings, our research equips educational institutions with a valuable tool for self-assessment. This model enables institutions to identify their strengths and weaknesses, fostering a culture of continuous improvement.

Since its inception in 2016, the NIRF ranking system has emerged as a vital national benchmark for higher education institutions in India. It sets a standardized assessment mechanism that promotes excellence and accountability in the education sector. Our findings offer institutions a clear pathway for

improvement, focusing on specific parameters that have the most significant impact on their rankings. This strategic approach can lead to enhanced competitiveness and overall growth in the higher education sector.

This research underscores the pivotal role of NIRF rankings in shaping the higher education landscape in India. It not only illuminates the critical factors influencing college rankings but also empowers institutions to enhance their standings, ultimately contributing to the advancement of the education sector in the nation. The NIRF rankings are more than just numbers; they represent a beacon guiding students, institutions, and society toward a brighter future in higher education.By observing all the parameters along with their subparameters, we made a table of all parameters with the algorithms that performed well and with the best train-test ratio.

Table 1.1: The performance of all the parameters along with the algorithms.

Parameters	Sub Parameters	Algorithm	MAE	MSE	RMSE	R^2	MAPE
TLR	SS	Random Forest	0.6613	0.97862	0.9828	0.80936	0.047298
	FSR	Linear Regression	2.57068	10.12833	3.1825	0.086748	0.10444
	FQE	Random Forest	1.3566	2.5791	1.6059	0.3827	0.094931
	FRU	Random Forest	2.67351	11.30979	3.363	0.30551	0.188837
RPP	RP	Bagging	1.0727	1.5969	1.2637	0.9935	0.046264
GO	GPH	Random Forest	3.3162	20.1595	4.48993	0.62517	0.166268
	GUE	Random Forest	1.01569	3.6998	1.9234	0.54611	0.029982
	GMS	Bagging	2.8859	11.034	3.321757	0.40473	0.26922
OI	RD	Adaptive Boosting	1.9877	15.94519	3.99314	0.81625	1.043568
	WD	Gradient Boosting	0.40039	0.55671	0.746133	0.811955	0.014925
	ECS	Random Forest	1.31606	2.39193	1.546558	0.54524	2.10017
PR	PCS	Bagging	1.06	2.618	1.618	0.807	0.087
	All	Linear Regression	0.9656	4.090117	2.022404	0.90465	0.01518

Table 1.1 represents all the parameter results with its best-performing algorithms and performance metrics. Here though we have calculated all the metric values we have considered MAE for selecting the algorithm with good performance. From the above result table, we can conclude that we have mixed algorithms concerning the parameters that are performing well and can be used for further process of predictions.

1.5. Conclusion

We have developed a predictive model based on our analysis of NIRF parameters to forecast scores and rank in advance. This model not only serves as a powerful tool for colleges to gauge their institutional development but also contributes to the broader advancement of higher education in the country. Our research presents an innovative approach, utilizing machine learning, as an alternative to the traditional methods employed by the NIRF organization for college rankings. By harnessing this model, colleges gain insights into their areas of improvement, enabling them to enhance their scores and, consequently, their rankings. This proactive approach fosters a continuous cycle of improvement, ultimately leading to higher rankings for educational institutions.

Table 1.5: The predictions values NIRF Parameters

Secured_ SS	Predicted SS	Total_RP	Predicted RP	Secured FQE	Predicted FQE	Secured WD	Predicted WD
16	15.889	39.24	39.24	15.84	14.9446	30	29.9653
18.73	17.5949	39.43	39.43	12.03	12.8248	30	30.0054

In the above Table 1.5, we have predictions done using our analysis of the year 2019 of Miranda House and RSG College of Arts and Science.Here we can see most of the values deviate very minorly,thus can be proved that this analysis and model can be used for the predictions of NIRF scores of colleges.

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