A Decision Support System for Student Placement Prediction and Early Career Guidance

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Abstract
Due to an increase in number of applications and intense competition in the campus placements, assessment of students' preparedness for placements and their appropriate career choices, has become absolutely essential. This project aims at developing a decision support system based on machine learning algorithms to predict students' placements and career planning. Through pertinent parameters such as cumulative grades, Communication skills, Coding abilities, Projects, Training Program attended, CGPA and Backlogs, students' employability skills are identified. This approach estimates the possible salary, probability of getting placed, make use of classification and regression techniques of Random Forest algorithm, and also suggest the companies best suited to recruit. With skill gap analysis and suggestion by the system, students will be able to development action plans and be well prepared for campus placement. There are 3 modules, the admin dashboard for placement check, batch predictions for a set of students and a single student prediction for an individual, configured with the proposed system. The system can be run as an web application, constructed using the Streamlit framework, which presents instant visualisation, prediction, reporting, and decision support. The trial results show that the Random Forest algorithm has generated encouraging results in predicting students' placements.

Keywords- Placement prediction, career guidance, machine learning, random forest, decision support system, educational data mining.

INTRODUCTION

Campus Placement is an crucial indicator of institutional performance and the employment prospects of its undergraduates. In view of plummeting margins, it is prudent for ambitious students to synchronize scores, occupation skills, interpersonal skills, practical projects and domain skills. Knowledge gain, suitable counseling and coaching at an early acquaintance probe, will nurture students practical skill and hence, meet ideal employment prospects. In recent days, mining the historical placement data of students as well as with the help of machine learning technologies has mitigated the prognosis of placement to some extent. In rest of the research studies, for the placements, algorithms like Random Forest, KNN, SVM, Decision Tree, Logistic Regression, Naive Bayes. But, all the existing models are far away away from neglecting the career counseling, skill development and decision support of the whole institution for recommending a student. To do so, this paper proposes a machine learning based decision support system to predict the student placement and give early career guidance. In this system, several attributes like communication skills, coding skills, CGPA, backlog ratio, training program, project experiences, and examination score. A dataset of 4,351 college students collected from college and placement cell has been employed for training and testing. Random Forest classifier is employed to predict probability of placement, recommend appropriate companies, estimate pay package and analyze skill gaps. Three key modules make up this system. The Single Student Prediction module gives personal placement report (company list suggestions, pay estimation, skill gap diagnosis, and career guidance). The Batch Prediction module calculates consolidated placement report and facilitate bulk batch analysis. The Admin Dashboard provides extensive institutional insights (such as placement count, type of company, salary scale and overall student readiness level) for effective planning. To make it practically feasible, the fully trained model has been embedded into a web app developed with Streamlit. The user-friendly fully functional site can be accessed by students, staff and placement team for report making, visualization and actual prediction. The observed outcomes show that the RF classifier best performs among many traditional and modern algorithms, with 81.40% accuracy. Overall, this

work is a comprehensive decision support system that creatively presents advice, counseling, institutional insight and forecast.

OBJECTIVES

- To predict whether the student will be placed or not and their probabilities.
- To predict the estimated Salary Package and recommend their compatible hiring companies based on student's profile.
- To perform the skill gap analysis and present individual student recommendation for better enhancement in skill, increasing their employability and placement status.
- To design the integrated system with Three Modules: Single Student Prediction, Batch Prediction and Admin Dashboard for monitoring and visualizing placement.
- To propose the trained model as a Streamlit application to make its accessible for predictions, Visualization, Report Generation, and Decisions.
- To assess the system's performance using evaluation parameters such as accuracy and to compare with existing machine learning algorithms.

LITERATURE SURVEY

The authors of [1] used supervised machine learning methods like Random Forest, SVM, Decision Tree, and Logistic Regression to create a Student Placement Prediction system. Using student academic and placement data, their study evaluated these models' performance and discovered that Random Forest outperformed all other tested algorithms in terms of accuracy. To forecast student placement outcomes based on academic records, credits, backlogs, and other placement-related factors, a Campus Placement Prediction and Analysis system was proposed in [2].The Random Forest algorithm is substantially superior than any other model for identifying pupils' likelihood of being placed basing on the data. To design a system for predicting students' employability, the authors of [3] constructed a Placement Prediction System utilizing a Machine Learning algorithm. The system tested both the academics and the talents in the dataset in order to determine how effectively the several algorithms could forecast placement. The hybrid Placement Prediction and Skill Recommendation System was proposed in [4]. In addition to predicted placement features, the system analyzed academic accomplishment, programme owned, professional achievements, and technical skills in order to identify potential skill shortages and generate customized recommendations for enhancing employability. [5] authors introduced a Placement Prediction and Analysis system that was intended to analyze employment trends and placement factors through evolving machine learning algorithms. Several classification algorithms were used to identify the significant factors affecting student placements and facilitate more efficient institutional planning. They all lead to the conclusion that most of current research is either confined to foreseeing placement results or constrained to offering fundamental recommendation assistance. The best models have astounding precision but overlook more systemic issues such as proficiency development, career counseling, salary prediction, and institutional analysis. Generally, all the programs are not designed to form part of an integrated placement ecosystem but aiming at a specific objective. There is an established need for an integrated and intelligent decision making aid system with placement prediction, company recommendation, salary prediction, skill-gap analysis, career counseling, batch-level assessment, and administrative Analytics. The endeavor to develop such an integrated framework assisting educational institutions and learners in making fact-based, effective placement, and career choices seems essential.

PROPOSED SYSTEM

A. System Architecture

In order to forecast placement outcomes and offer insightful career assistance, the proposed Placement Decision Support System integrates machine learning algorithms with a web-based analytics interface. To facilitate decision-making at the individual and institutional levels, the system is built with several functional modules, such as Student Prediction, Company Recommendation, Package Prediction, Skill Gap Analysis, Batch Prediction, and an Administrative Dashboard.

B. Placement Prediction

A Random Forest Classifier is used for placement prediction. Various student data are considered by this model, including communication and coding abilities, academic achievement, CGPA, project experience, training involvement, and backlogs. The system classified students based on their degree of placement preparation and tells placement likelihood based on those inputs.

C. Company and Package Prediction

A Classifier of Extra Trees is used to recommend appropriate recruiting agencies to the student which would help provide him/her with more detailed information about a prospective position. Average package estimates are made here as well, however, using a Random Forest Regressor. This helps the student determine the expected salary range and the kinds of jobs he/she is likely to get.

D. Skill Gap Analysis and Career Guidance

The system examines the profile of students and highlights the deficiencies in certain significant aspects like communication skills, coding skills, grades, project experience etc… It subsequently offers tailored advice and suggestions to increase the employability and placements opportunities in students.

E. Batch Prediction and Administrative Dashboard

The Batch Prediction module helps us to have in-depth placement data and also gives the possibility to analyze a number of students for research purposes. Salary patterns, recruiting trends for each of the firms, overall placement data, comparative measure of students' preparedness, and so on are some of the important useful reports that can be generated using the Administrative Dashboard. This helps us in concerned placement decisions.

F. Streamlit-Based Web Application

The current solution is also developed using Streamlit to build nice and intuitive web interface. This platform will be utilized for real-time prediction, batch processing and analysis, data visualization and report creation in pdf format. Therefore, the system is effective, useful and easy to use by students, faculty members and hiring industries.

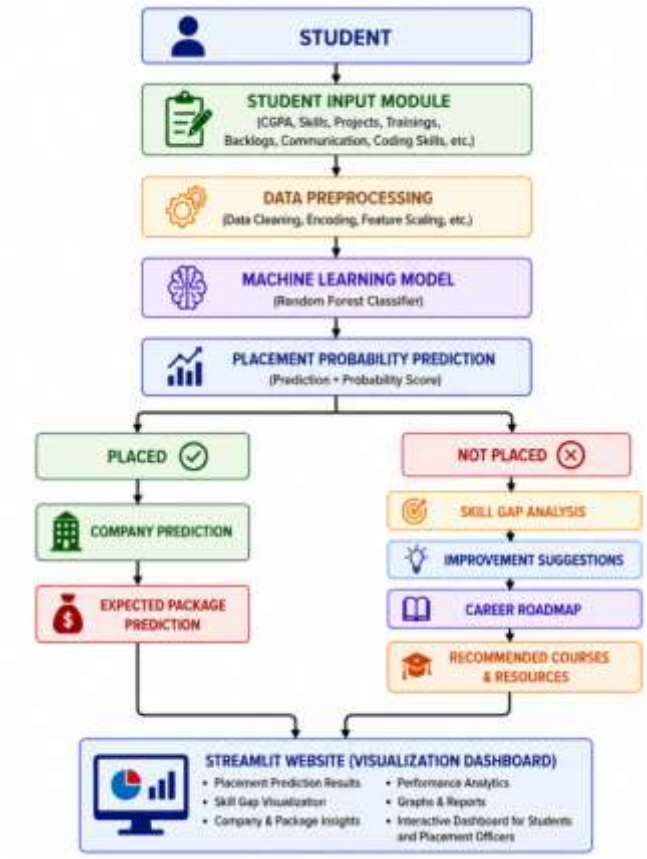

Fig 1: System Architecture

METHODLOGY

PDSS makes use of machine learning to predict the outcome of the placement, recommend appropriate recruiters, decide the package wages and others career coaching etc…The methodology can be summarized in following five broad categories: data collection, data preprocessing, feature extraction, modeling and evaluation.

A. Data Collection

The data required for the project was extracted from the academic databases and the institution placement records. It consists of 4,351 students' records containing their academic communication skills, coding skill, project experience, training received, CGPA, backlog details, placement, company placed and wages package details. Such a wide range of features can be exploited to design an optimal placement prediction and analysis model.

B. Data Preprocessing

Preprocessing operations were carried out in an attempt to preserve the data's original properties and improve the model's performance. Imputation was used to detect missing data and removal of duplicate data. Encoding techniques were used to translate the categorical data into numerical data that ML algorithms can understand. This produced a Cleaned data file in the required format for training the models.

C. Feature Engineering

The critical attributes which mostly influence the outcomes of placements were identified through this process. Few of the attributes were communication, coding, aggregate, project, CGPA, training, backlog. These were used as input attributes to train the model to predict the package, company and the placement target. A third level of feature engineering was to combine related subjects into a more useful skill based score in order to accurately represent student capabilities: Communication Skills Score was the average of ELCS and AECS.

Average of the PPS and PPS LAB programming score was used to compute the Coding Skills Score. Performance on hands-on and project based learning earned an EEP Score which was averaged across the three courses, Engineering and Project Skills (EEP), Information System and Integration (ISI), Senior Innovative Project (SIP). As a indicator of students academic strength, an Academic Performance Score was derived by an average of all the core subjects. This change would eliminate redundancy, reduce data and provide a more transparent and simplified profile of the students skills.

D. Model Development

Three machine learning models are built (Random Forest Classifier to Predict Placement Status, Extra Trees Classifier to choose the best business, Random Forest Regressor to predict Salary Packages) for three purposes respectively. Data are split by 80:20 into training set and testing set for fitting these models on holdout dataset.

E. Performance Evaluation

Our developed models were measured on typical performance metrics such as Accuracy, Precision, Recall, F1-Score & Confusion Matrix. The accuracy of placement prediction model of 81.40% poses an improvement attributable to the proposed data representations and models. Apart from academic data in raw form, feature engineering also played an important part to boost the performance of our models. The dataset attained fine aggregation and significance after grouping of related subjects into skill-based features of students. This inputs instead of actual subject scores would enable the model to better interpret students' aptitude and perform consistently with less data noise and better generalization.

ALGORITHMS USED

Three of the machine learning algorithm are introduced to arise three different prediction task to make accurate position analysis and complete guide to the career.

A. Random Forest Classifier (Placement Prediction)

The scheme shown below elaborates the random forest classifier, which were the most widely used classifier for placement prediction. Random forest classifiers are a type of ensemble learning method, where multiple decision trees are built at training time, and output the class which is the mode of the classes (classification) or mean prediction (regression) of the individual trees. Random forest classifier with several features of the students CGPA, communication skills, coding skills, academics, project experience, training, backlog have been tested for predicting the placement. The experimentally results proved the RF classifier gave the maximum prediction of 81.40% accuracy and thus used for placement prediction.

$$\hat{Y}=\text{mode}\{T_1(X),T_2(X),...,T_n(X)\} \quad (1)$$

B. Extra Trees Classifier (Company Recommendation)

Extra Trees(Extremely Randomized Trees) Classifier is used to recommend appropriate recruiting organizations based on student`s profile and technicalities. Extra Trees, is totally Randomized Trees when compared to Random Forest. Like Random Forest but far more Randomized in choice of decision tree where cut-points are chosen at random. This averaging of predictions results in reduction in variance, and speedier training times. Existing classifier works on students skills and so many competencies and suggests organizations to students.

$$\mathbf{Gini_{split}} = \frac{N_L}{N}\,\mathbf{Gini(L)} + \frac{N_R}{N}\,\mathbf{Gini(R)} \quad (2)$$

C. Random Forest Regressor (Salary Package Prediction)

Random Forest Regressor shall be used to forecast salary package of placed student. It is a regression model and it computes the continuous value of salary by averaging out the results of large decision trees. It considers various parameters like student grades, technical knowledge, project work, internships, communication skills, overall performance in placements etc. To provide a probable salary range. This predicted Salary helps student set up a target for planning career.

$$y = \frac{1}{n}\sum_{i=1}^{n} T_i(X) \quad (3)$$

D. Algorithm Selection

For placement prediction task, 7 machine learning algorithms including Logistic Regression, Decision Tree, KNN, SVM, Naive Bayesian and Random Forest were tested. Random Forest gave highest accuracy of 81.40%. So it was used as the classification algorithm in the final model.

RESULTS

Several machine learning techniques, such as Logistic Regression, Decision Tree, K-Nearest Neighbors (KNN), Support Vector Machine (SVM), Naïve Bayes, and Random Forest, were used to test the proposed Placement Decision Support System. To determine the best method for forecasting student placement outcomes, each model was trained and assessed using the prepared student placement dataset. The Random Forest algorithm was chosen for implementation in the finished system since the experimental results unequivocally demonstrate that it performed the best overall.

A. Model Performance Comparison

The performance of various machine learning techniques for placement prediction is displayed in Table I.

Table 1: Comparison of machine learning models

Algorithm	Accuracy (%)
Logistic Regression	79.91
Random Forest	81.40
Decision Tree	79.10
KNN	78.99
SVM	80.60
Naïve Bayes	73.94

Table I compares the accuracy results of various ML algorithms considered for the task of predicting students' placement. Among all models considered, the Random Forest has reported the highest accuracy of 81.40%, supported by the Support Vector Machine and Logistic Regression having accuracy 80.60% and 79.91%, respectively. Decision Tree and K-Nearest Neighbors recorded close accuracy, which is 79.10% and 78.99%, whereas Nave Bayes reported the minimum accuracy 73.94% among the tested models. Hence, the Random Forest algorithm was chosen to develop the final prediction model owing to its high predictive performance, resistance to over-fitting and ability to manage the relationships among variables.

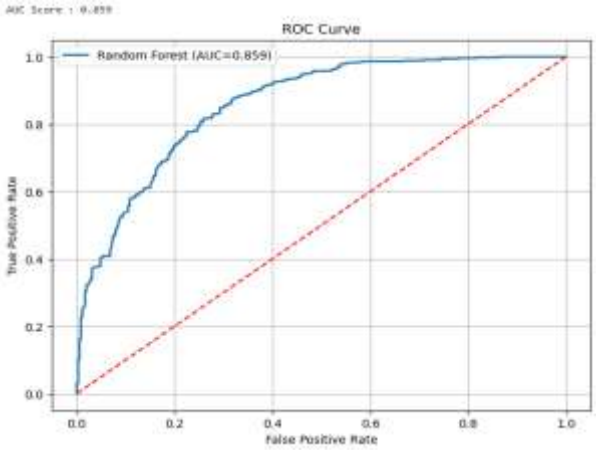

Fig 2: ROC Curve for Placement Prediction using Random Forest.

Fig 2 illustrates the ROC curve of the Random Forest classifier. The model achieved AUC score of 0.859, indicating excellent discriminative ability between placed and non-placed students. An AUC value close to 1.0 demonstrates that the model can effectively differentiate between the two classes across different classification thresholds, and validating its robustness and reliability for placement prediction.

B. Confusion Matrix

The confusion matrix obtained from the Random Forest model is given below:

Table II: **Confusion matrix and classification report of random forest**

Actual / Predicted	Not Placed	Placed
Not Placed	219	96
Placed	66	490

Class	Precision	Recall	F1-Score	Support
Not Placed	0.77	0.70	0.73	315
Placed	0.84	0.88	0.86	556

Table II is the confusion matrix and the classification report of the suggested Random Forest model. It demonstrates that the confusion matrix provides accurate results by 490 placed students correctly classified and 219 not placed students accurately classified. However, there are 96 not placed students misclassified as placed, and 66 placed students are predicted as not placed. Classification report illustrates further how well the suggested Random Forest model perform, based on the calculated metrics for both class; Placed achieved 0.84 precision, 0.88 recall, 0.86 F1-score, whereas Not Placed achieved 0.77 precision, 0.70 recall, and 0.73 F1-score.

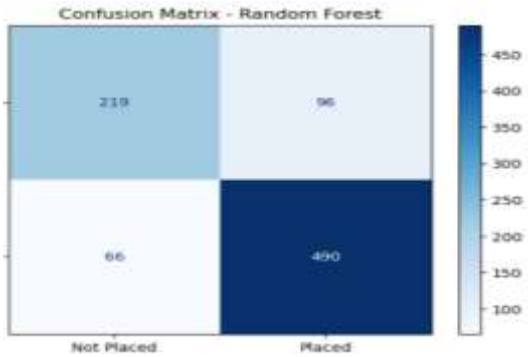

Fig 3: Confusion Matrix

The confusion matrix above illustrates the fact that the predicted model can be able to perfectly predict most of the placed student, but still have acceptable result with the not placed class. From the classification report, the prediction and recall of the Placed class were good, and the average F1-score of the model was 0.86, so Random Forest Model is quite efficient.

C. System Implementation Results

The system is implemented using Streamlit and integrated with the trained Random Forest model. It provides an easy to use web interface that converts machine learning predictions into practical.

1) Student Prediction Module

Individual students can enter academic and skill-related data into the Student Prediction Module to receive tailored career advising, company recommendations, expected package estimation, placement status, and placement chance.

Fig 4: Student Prediction Interface

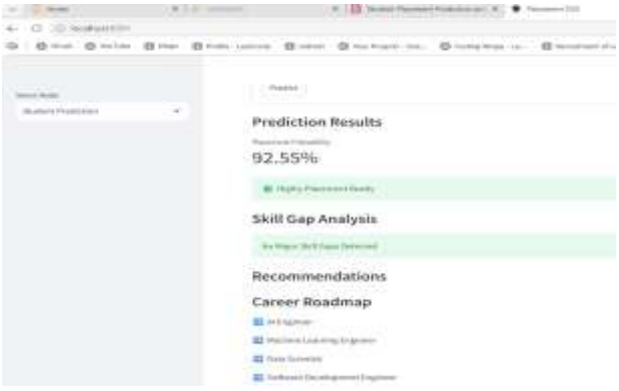

Fig 5: Student Prediction Results

2) Batch Prediction Module

In this multiple students can check their placement status at a time and their possibilities of getting placed or not and also can know their improvement areas and prepare according to that.

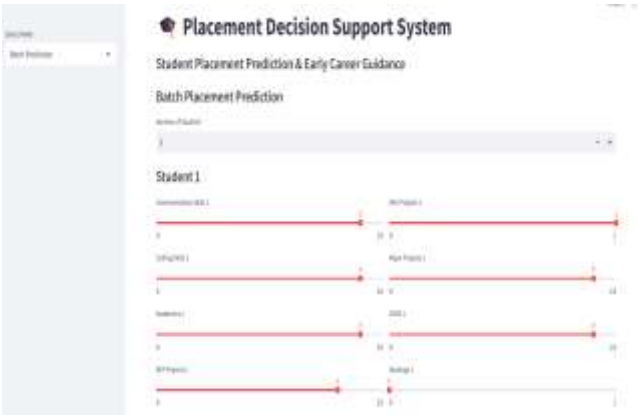

Fig 6: Batch Prediction Module Interface

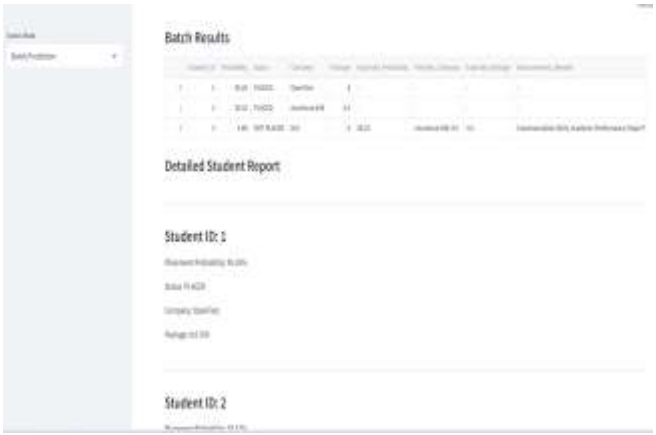

Fig 7: Batch Prediction Module Results

3) Administrative Dashboard

Through visual analytics, the Administrative Dashboard offers placement statistics, recruiter analysis, readiness distribution, and placement %. These findings help placement officers organize placement activities and keep an eye on students' employability.

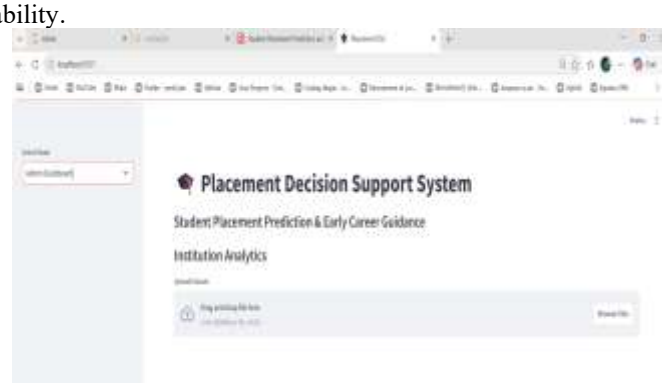

Fig 8: Admin Dashboard Results

Fig 9: Admin Dashboard Results

Discussion

The findings of the experiment confirmed that the placement decision support system, designed by using machine learning approach to facilitate the student placement process, can effectively predict student placements and generate guidance regarding students' career paths. Moreover, we got better predictive performance using random forest classifier and the prediction accuracy is about 81.40% and AUC is 0.859. In a single place of UI, or designed model not only helps to predicts placement but also provides information to students and universities like company recommendations, placement related analysis and so on by bringing placement prediction, company recommendation, salary estimation, skill gap identification, batch prediction, administrative report in the platform (built using Streamlit).

CONCLUSION

The paper gave an end-to-end Decision Support System for Student Placement Prediction & Early Career Guidance via machine learning approaches. The system integrated all the aforementioned requirements-Placement prediction, company recommendation, salary package prediction, skill-gap analysis, batch recommendation as well as visitor analytics into single system as Decision Support System for students & placement administrators. A number of machine learning algorithms have been used for the implementation of the system. Random Forest Classifier for candidates suitable for the placements, Extra Trees Classifier for the most suitable companies to the candidate, Random Forest Regressor for the salary package. All of these algorithms are provided each profile of the students with one or more of the following features: the features of the students and then they perform personalized predictions and recommendations about the career for each of the students. Feature engineering techniques are used to improve the model prediction.

According to the experiment, the best prediction accuracy of Random Forest Classifier was 81.40%. It was better than other models as Logistic Regression, Decision Tree, KNN, SVM, Naïve Bayes. The results show that this classifier model have been good classified of all measures as Precision, Recall, F1-score and Area Under the ROC Curve (AUC).

The system can also be used for some very practical applications of practicing and helping the students, for example by identifying the skills that are lacking in a particular student, or suggesting the companies to the students for recruiting, calculating the expected salary packages of the students, and providing Career guidance for the students on a one-to-one basis. The Batch Prediction system can also be used by a college on a large scale to check the placement readiness of a batch of students. The colleges Administrative Dashboard can be used to monitor the placement trends, participation by various companies etc.

All things considered, our decision support system in pure design provides an effective academic decision support system which can fills the gaps between academic and employment field, so that students can take right decisions, but educational institutions can optimize placement activities and increase students' employability.

FUTURE ENHANCEMENTS

This suggested individual Placement Decision Support System would be a sound foundation for wise placement prediction enabling some more modifications with investigation on this scalable framework and prediction performance. Further scientific researches may focus on more wise models such as furthermore ensemble learning, deep learning, AI-XAI: XGBoost, LightGBM, CatBoost classifiers, ANNs (artificial neural networks), even Transformer-based models, etc.

From the deployment point of view, the framework can be further extended to the cloud base and mobile applications, so that anytime-anywhere availability can be provided to students, faculty members and placement officers. Cloud deployment will be helpful from Centeralized data management, better scalability and multi-institution deployment. And also, it can be further enhanced to automate the retraining of the model. By doing this, the machine learning system can learn from the real placement data on a periodic basis, so that it always maintain a high predictive accuracy of the changing recruitment trend. And the explainable AI algorithms (e.g., SHAP or LIME) can be explored, to improve the interpretability of the placement prediction and recommendation, therefore make it more reliable to the end users. Overall, these enhancements may create a fully AI Career Intelligence system for the suggested framework providing accurate prediction, personal recommender and fact-driven placements to students, education institutions and recruiters.

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