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Prediction of recommendations for employment utilizing machine learning procedures and geo-area based recommender framework

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ABSTRACT

With increment in the utilization of Internet, the pace of increment of social networks is getting ubiquitous in recent years. This paper focuses on the job portal websites. The research objective of this paper is that the recommender framework takes the abilities from the website and makes suggestion to the candidates with the jobs whose descriptions are coordinating with their profiles the most. This paper additionally presents a short presentation on recommender framework and talks about different categories of this framework. From the start, information is cleaned by expelling the filthy information as extra space and duplicates. Then the job recommendations are made to the target applicants on the basis of their preferences. It utilizes different Machine Learning procedures which results show that Random Forest Classifier (RFC) gives the most noteworthy expectation accuracy when contrasted with different procedures. Finally, the optimization technique is utilized to get the most exact outcome. The advantage of recommender framework in career orientation is expressed. Geo-area based recommendation framework is utilized to find the organization's position which can assist the ideal applicants with reaching their destination. This examination shows that the utilization of job recommender system can assist with improving the recommendation of appropriate employment for work searchers.

1. Introduction

With the appearance of joblessness expanded in the present situation, there must be an appropriate framework to recruit the job aspiring candidates. People are getting too many options which make them difficult to differentiate among various jobs. This leads to information overload. To lighten this issue, an information filtering tool is presented which fundamentally filters the jobs using the candidates profile and company needs. Recommender system [1] is nothing but a decision making tool that recommends products based on user's preferences or interests. It acts as an information retrieval tool that helps to filter out and prioritize the data. The framework at that point suggests the job seekers with proper jobs that are appropriate for them and matches their profile as needs be. Job recommender framework subsequently goes about as a middle person between the job aspiring candidates and recruiters.

The research objective of this paper is that the recommender framework takes the abilities of the candidates from the website and makes suggestion to them with the jobs whose descriptions are coordinating with their profiles the most. It consequently connects the candidates with the job offers for employment using recommendation system. This framework spares a great deal of time by coordinating the job aspiring candidates with the proper job offers. In current society, immense measures of data are accessible in the web. With this individuals are getting lot of choices to follow. Along these lines, there is a need of legitimate framework that will assist the individuals with distinguishing among right items or substance as whether it is important to go with that or not and take choices as needs be. Recommendation system here assumes an indispensable role to find the new items or substance by anticipating the exactness of each item. It suggests the items that have the most elevated precision and are like different things present in that rundown. It utilizes the inclination of users that they provided for an item or content.

This study is confined to the users mainly evolved in the process of recommending the jobs from the job portal websites. An enormous measure of data is given in which data is filtered through to get the specific highlighted information. This data provides the details of the company status, its employee's details, age of the employees, salary, position duration and the number of staffs in the company. It focuses on each of the attributes of the information provided and recommends the jobs to the candidates in like manner. The organizations over the world use job recommender framework to recommend appropriate job to the job aspirants utilizing the featured information.

This investigation provides the better recommendation for career orientation as compared to traditional system. The recommendation framework takes the users information to make user profile. This helps to predict the appropriate company for the candidate and the company gets

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its required employee directly without burning through such a great amount of time in enlistment process. The framework utilized by numerous organizations over the world needs the significant information about the candidates to recommend them right from the beginning. It reduces the time conflict hence, helps the candidates to get their right career alternatives. It traces information about the users using their attributes, preferences, likes and inclinations.

Recommendation system [2] is particularly essential tool for customized proposals. It helps user to get their required needy things in a trouble free way. It helps the users from multiple points of view, for example, online exchanges, showcase part, motion pictures recommendations, work proposition and some more. As in this day and age, individuals have assortment of alternatives to get their relevant information or data due to the far reaching of the web. Along these lines, to tackle this issue, recommendation plays a crucial role to get out of it by recommending the top items to the users. Numerous organizations around the globe utilize these recommendation algorithms to recommend the items, jobs, employments and so forth. It helps those organizations to increase an enormous benefit by giving the ideal recommendation to the users. Similarly using job recommendation system by companies, the recruitment process starting from selecting a right candidate to giving him an appointment letter, makes the procedure simpler. The recruitment process takes great deal of time via looking through individual profiles and abilities form huge amount of data. The result is not always giving the right candidate to right job opportunity. The immense increase of internet which gives prevalence to the use of E-enrollment uses job recommender system by companies which helps the job applicants to get better carrier options which matches their profile. It diminishes the hour of enrollment process henceforth, makes the procedure reliable.

The research objective of this paper is that the recommender framework takes the abilities of the candidates [6,8] from the website and makes suggestion to them with the jobs whose descriptions are coordinating with their profiles the most. It will recognize patterns in the research of machine learning algorithms in recommender systems.This study is confined to the users mainly evolved in the process of recommending the jobs from the job portal websites.Job recommender framework gives a way to job seekers to get their relevant jobs and recruiters to get their skilled employees. It gives a way to users to get their customized proposal without using a great deal of time.

Recommender framework is useful from multiple points of view:

i It assists with limiting the ideal opportunity for picking and choosing the items from online condition so without any problem.
ii Decision-production process is redesign as a result of recommender framework.
iii It gives a way to users to get their customized proposal without burning through a great deal of time.
iv It is utilized in such huge numbers of different areas, (for example, books, media, places of work, travel, games, eatery and so forth.) to suggest the clients.
v Job recommender framework gives a way to job seekers to get their relevant jobs and recruiters to get their skilled employees.
vi It consequently connects the candidates with the job offers for employment using recommendation system.

2. Related work

2.1. Introduction. to recommender systems

A lot of research works have been carried out in the field of recommender system. F.O. Isinkaye et al. [1] discusses various aspects of recommender system. It provides more emphasis on filtering techniques of recommender system. It uses statistical accuracy metrics for the filtering techniques by distinguishing actual ratings with predicted ratings. Gediminas Adomavicious et al. [2] presents an overview on various domains of recommender systems. It provides brief information on current approaches and techniques of the recommender system including the limitations and extensions. Shuo Yang et al. [3] discuss the various aspects related to content and collaborative filtering techniques. It combines both the techniques to get the hybrid technique. The model is built by using statistical relational learning (SRL) for representation of probabilistic dependencies.

2.2. Use. of machine learning in recommender systems

Sidahmed Benabderrahmane et al. [4] proposed a decision making tool to provide a path to recruiters which help them to get the efficient job seekers. It represented a Doc2Vec embedded system which stores the information of clickstream history of job seekers in the database. It also uses deep neural networks to get the future prediction of clicks using various job boards database. It overcomes the problem of over fitting using dropout layers. Nedra Mellouli et al. [5] in similar context represented a smart4job recommender system that connects the job aspirants with job offers that matches their profiles the most. The model works on temporal prediction and domain knowledge analysis. Miao Jiang et al. [6] further improved the model by introducing email mode. In this system, the candidates provide their resumes to get email alerts about the new job offers. But these above models partially explain the context. To resolve this issue, Priscila Valdiviezo Diaz et al. [7] uses Bayesian model for the recommendation process. This model based on collaborative filtering method which uses user-item correlation. The collaborative filtering technique builds a database of users' interests. It then matches those relevant interests with other similar users to make accurate recommendation. This kind of users basically makes a group consisting of more number of users. Shibbir Ahmed et al. [8] introduce an online recruitment system that will use by recruiters to get the efficient candidates. It uses hybrid filtering technique between training and testing dataset. It selects top job offers as the recommended list and makes selection based on that. Shiqiang Guo et al. [9]. proposed a system named as ResuMatcher. It basically matches the resumes with the corresponding job offers. It uses machine learning techniques to get the effective results. This paper also deals with natural language processing (NLP) for the recommendation process.

2.3. Social. network based job recommender systems

Although the above models have achieved significant improvements as compared to traditional models using various filtering techniques. But there is a need to recommend socially which includes friends of similar interest. Mamadou Diaby et al. [10] use Facebook and LinkedIn dataset for the implementation of their work. The system collects the information about the users from social networks for recommending suitable jobs to them. It represents architecture for taxonomy based job recommender system. But the limitations are that some information is in private mode which leads to wrong assumptions. Linear SVM needs to be trained for accurate predictions. Fan et al. [11] introduced a graphical network named as GraphRec for recommendation using social networks. It uses interactions and opinions of users for the recommendation process by modeling the graph data. Ma et al. [12] also discussed about social networks including latent factors. It focuses on matrix factorization to improve the recommendation results. But there is still needs to explore the various tools and techniques for better social recommendation.

3. Proposed framework

By understanding the above observations, we propose various machine learning classifiers [13] to improve the performance for recommendation. These classifiers predict the accuracy of the given database. It helps in modeling the mapping function from input variables i.e. X to target or output variable(s) i.e. Y. Machine Learning is a type of learning that automatically learns from experience [14]. There is no compelling

reason to explicitly compose each and every instruction for the machine to perform. It uses some of the training data to get the information about the input variables. These variables help the job seekers to get the jobs as per their features. When the classifiers are trained with accurate values, it can be used to recommend the suitable jobs. To get the effective result with more precise value, we have used stratified k-fold cross validation [15] technique to optimize the prediction accuracy. It helps us to reach the superior classifier which will be used by my companies to get the efficient jobs seekers. Later on, we have presented geo-area based recommender framework [16] to get the area of the ideal organizations. It straightforwardly demonstrates all the possible nearby area of the organizations which will help the job aspirants to arrive at the reasonable organization close to his/her zone. In the experiment, we have evaluated our proposed method using two different social networking datasets and get the highest prediction accuracy in same classifier in both the datasets.

The proposed model deals with the candidates data that is provided in the form of resume and bio data. This information's are gathered from various social networking sites and used by recruiters who wish to provide the job offer to them. The entire work is divided into top and bottom methodology. Top approach basically deals with front end whereas bottom approach deals with back end. A wide range of job boards provides the details of candidates as well as companies. Thus, a valid data set is collected for working of the procedure. The data set is stored in the database for further process. As the data set is already reduced form Hadoop map-reduce function, it uses machine learning for the implementation of the model.

This framework uses various machine learning techniques to showcase the prediction accuracy. The top part contains all the back end work whereas the bottom includes the front end work. Analysis and visualizations of all the features is carried out. Performance of the database is measured using machine learning classifiers which show that random forest classifier give highest prediction accuracy when contrasted with different classifiers. The results are then optimized to get exact classifier to use for the recommendation process. The machine collects the applicant's details and applies RFC algorithm to recommend the desired job offers using Job recommender engine. Consequently, different organizations over the world can utilize this job recommender system to recommend top ranked job offers.

To assist the competitors with reaching their objective, the framework utilizes geo-area based recommender framework. This framework mitigates the issue of diverting from organization's area. The job seekers can utilize this framework to arrive at the organization's area by following it in the geo-map. The outcome will give the organization's precise area. Fig. 1 illustrates the proposed model for the evaluation of the job recommendation process.

4. Data preprocessing and validation

4.1. Dataset. source

In this job recommender system, we have considered two job hunting datasets: LinkedIn and Facebook. LinkedIn dataset consists of 39,538 candidates with 26 job features. At first, feature extraction is carried out. The system extract the data The system extract the data from large dataset that will help further for recommending jobs to the candidates. After formation of final table, we consider only those features that are relevant to the candidates for proper recommendation. Candidates are dropped due to missing values in their job features. Thus, 39,535 candidates are selected with 8 job features. Age estimate give the age value that is required by the company. Company staff count describes the total staff in the company. Connections count shares the networks spread about the company. A specific id is provided to companies known as position id. Average member position duration is the time duration of each employee in a particular position. Average company position duration describes the position of particular company in global network. A company sometimes decides to provide shares at higher prices than face value is called premium. Company name is the registered name by which a specific company can be identified.

These features are analyzed using various machine learning classifiers. It is an analytical method used in the analysis of data for building of models. Machine learning is a subset of Artificial Intelligence. Feature extraction is the process of removing extra features from the raw dataset for processing. Similarly, feature analysis is also done for Facebook dataset. By considering the dataset is too large, 6425 features are selected with 7 job features after feature extraction process. Python is used as implementation language to get the prominent results for recommendation process. Various libraries are used to extract the data. NumPy is used to perform mathematical operations on the given data. Pandas is used to analyze the data. It import the dataset of CSV file to the Python platform. Matplotlib is used for visualization techniques such as to embed histogram, heatmap and scatter plot. Seaborn acts as backbone for Numpy and Matplotlib. All the features of LinkedIn dataset are traversed using different visualizing techniques. Frequency of each feature is displayed by histogram using kernel density estimate. Entire dataset is visualized using Heatmap to get the most used feature. This will help the system to get the most relevant job description to match with candidates. Scatter plot describes the relation between two different features.

4.2. Frequency. of features using KDE

Kernel Density Estimate is the method helps to visualize the distribution of feature in an efficient manner. Estimation occurs by using various parameters. Figs. 2 and 3 represents the density of age estimate and company staff counts occurred in the particular feature, respectively using LinkedIn dataset.

Figs. 4. and 5 represents the density of connection count and position id occurred in the particular feature, respectively, using LinkedIn dataset.

Fig. 6 represents frequency of the average member position duration occurred in each particular feature using LinkedIn dataset.

4.3. Heatmap. for dataset

Heat map is a 2- D matrix representation which shows the variation of values using colors. It uses the dark-to-light color scale to show which feature is used more. The most used feature by recruiters is represented using dark color whereas the least used feature is represented using light color. Fig. 7 represents the visualization of candidate's features for the LinkedIn dataset using Heat map.

4.4. Scatterplot visualization

Scatter plot is a data visualization technique that uses dots to display two different features of candidates in horizontal and vertical plane. It basically used to observe the coordination among different features of candidates. In this paper, we compare age estimate feature with other features to get the variation. It explains the coordination of age with other features of the dataset. The job will be suggested to candidates on the basis of their age prior to other features that match their profiles Fig. 8 shows the scatter plot representation among age estimate and company staff count features of the given dataset.

Fig. 9 shows the scatter plot representation among age estimate and average member position duration features of the given dataset.Fig. 10 shows the scatter plot representation among age estimate and position Id features of the given dataset.

Fig. 11 shows the scatter plot representation among age estimate and connection count features of the given dataset.

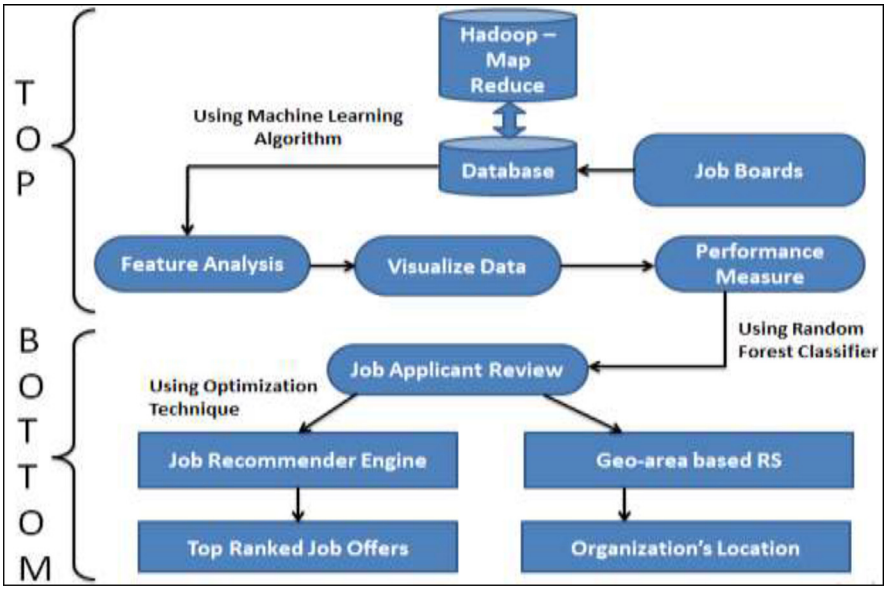

Fig. 1. The proposed model.

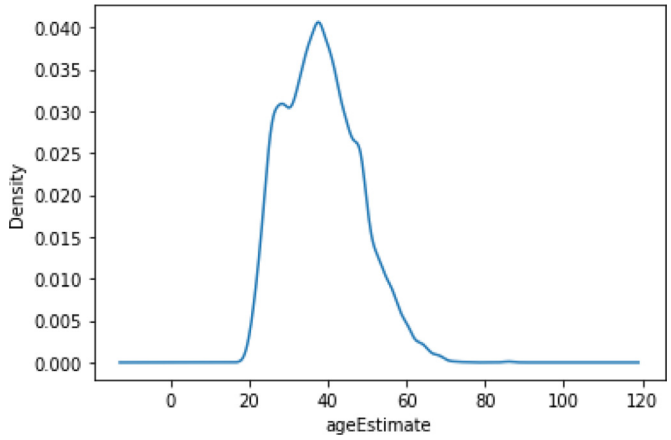

Fig.2. Density of age estimate.

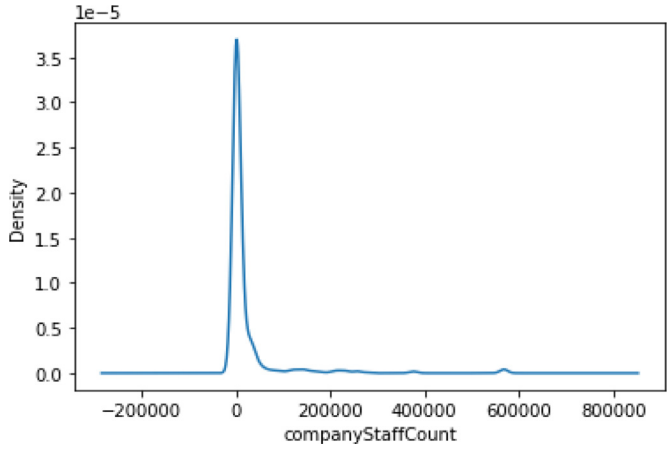

Fig.3. Density of company staff counts.

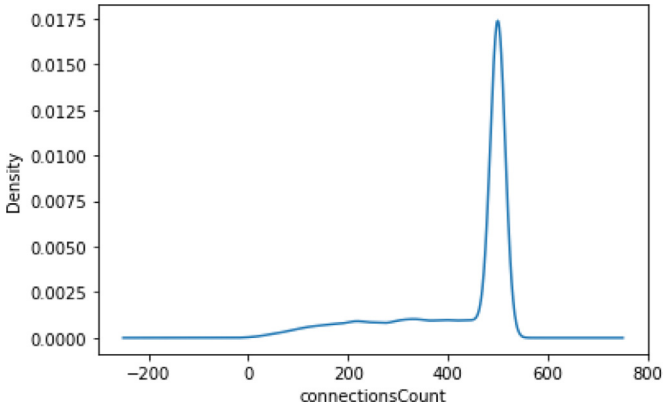

Fig.4. Density of connections count.

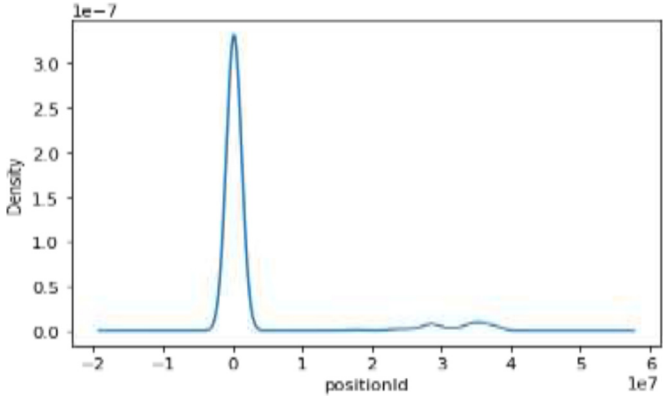

Fig.5. Density of position ID.

4.5. Methodology applied

Machine learning [17] is well-known as subfield of Artificial Learning (AI). The objective of machine learning is to comprehend the structure of information and fit that information into models that can be comprehended and used by individuals.Despite the fact that machine learning is a field inside computer science and engineering, it contrasts from conventional computational methodologies. In conventional figuring, algorithms are sets of explicitly programmed instructions utilized by system to compute or settle the issues. Machine Learning algorithms rather consider system to prepare on information sources and utilize

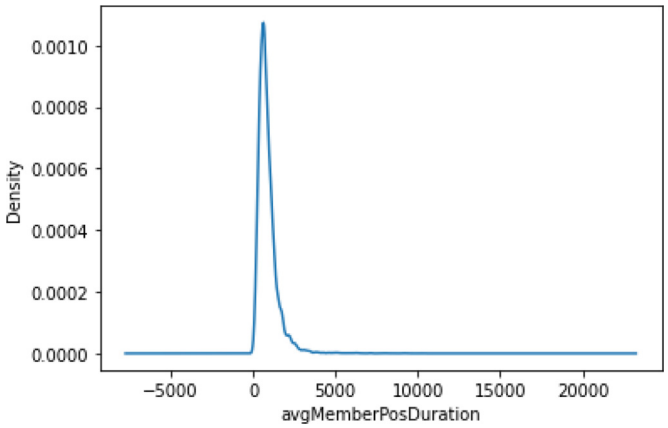

Fig. 6. Density of average member position.

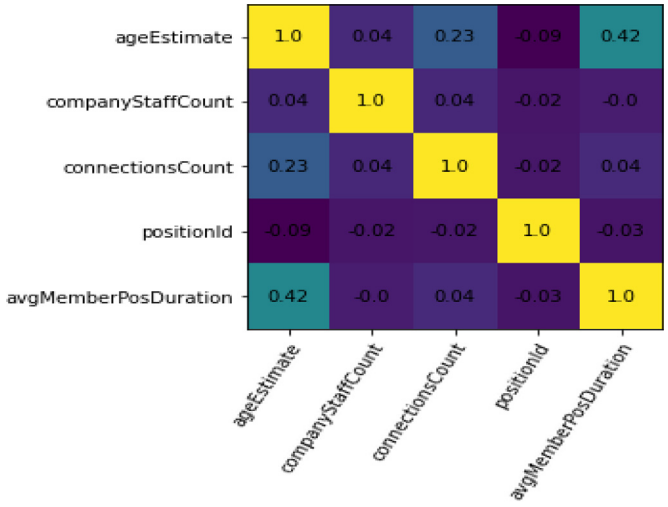

Fig.7. Heat map visualization.

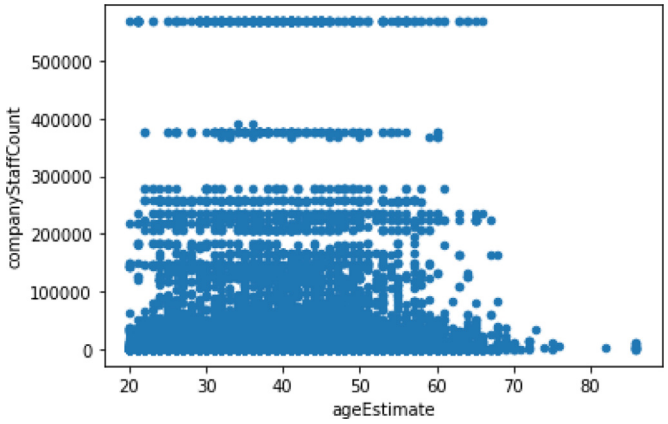

Fig.8. Scatter plot between age estimate and company staff count.

measurable investigation so as to yield esteems that fall inside a particular range. Along these lines, machine learning encourages system in building models from test information so as to mechanize dynamic procedures dependent on information inputs. A recommender system gives recommendations to the users through an ltering process that depends on user's inclinations and perusing history. The data about the client is taken as an input. The data is taken from the information that is through perusing and browsing information. The proposal framework is an execution of the machine learning calculations. It is a stage that

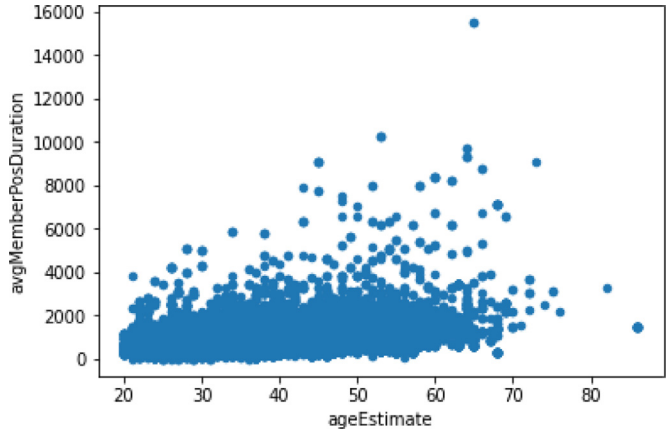

Fig.9. Scatterplot between age estimate and average member position duration.

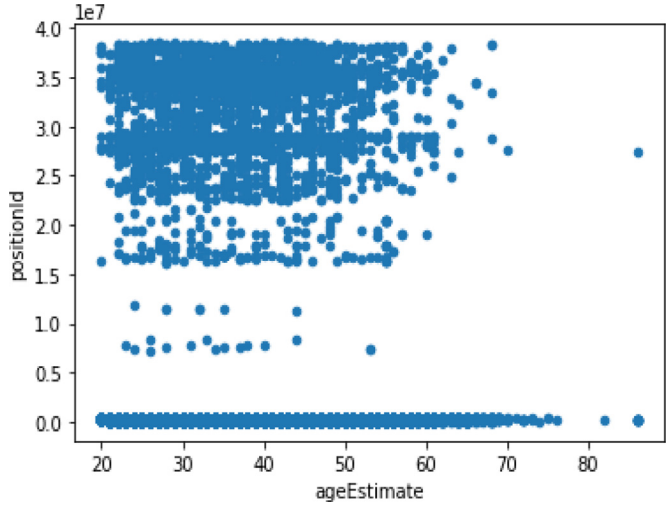

Fig. 10. Scatter plot between age estimate and position ID.

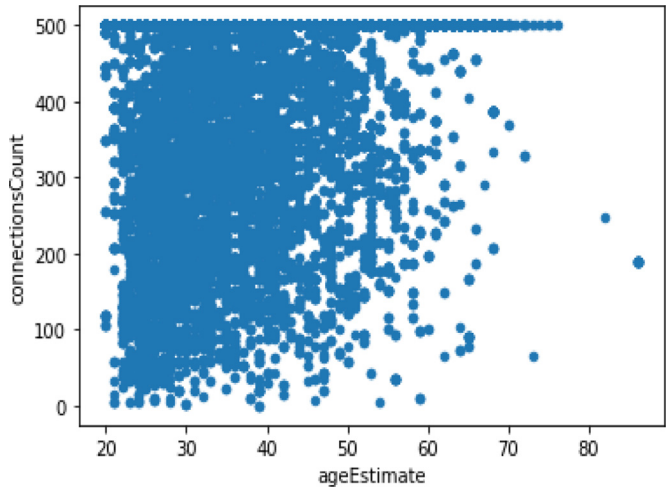

Fig.11. Scatterplot between age estimate and connections count.

gives its users different preferences dependent on their inclinations and likings. A recommender system thus, takes the data about the user as information. To limit the data over-burden, we use Machine Learning procedures. These strategies help the framework for better advancement results with exact qualities.Following are the machine learning classifi-

cation algorithms that are used to analyze the prediction accuracy in the datasets:

4.5.1. Logistic regression (LR)

Logistic Regression is a supervised machine learning algorithm that learns from training dataset. It is a type of algorithm that is used to predict the probability of target feature (Y) from the set of input features (X). The result is in the form of binary variable: true (1) or false (0). Thus, gives output as two possible outcomes. The logistic regression provides the best fit model that shows the relation between X and Y.

4.5.2. K nearest neighbors (KNN)

K Nearest Neighbors is a supervised classification algorithm that concerns with labeled points to train other label points. It related with points that are similar to each other. The majority of values provided by the neighboring points are used to get the classification result. K is the number of nearest neighbors (points) used for accuracy prediction.

4.5.3. Stochastic gradient decent classifier (SGD)

Stochastic Gradient is a machine learning classifier that helps to calculate the values from training data. The implementation process uses random sample instead of whole dataset. Thus, the process gives immediate result as compared to other techniques. The goal of this algorithm is to find minima or maxima by iteration.

4.5.4. Support vector classifier (SVC)

Support Vector Classifier is a supervised machine learning classifier which acts as a discriminative classifier. It is basically defined by separating hyper plane in an N-dimensional space. It minimize the error caused during implementation. The motive of using SVM algorithm is to find a highest margin plane so that future data points get more confidence value.

4.5.5. Naïve Bayes (NB)

Naïve Bayes is a classification technique known for generating learning classes. It is based on Bayes Theorem. The main goal of Naïve Bayes is to get the output with better prediction value. It is a combination of features that are independent of every other feature.

4.5.6. Multilayer perceptron classifier (MLP)

Multilayer Perceptron also known as feed forward artificial neural network consists of various layers for the operational work. Input layers are used to receive the signals as raw data whereas output layers provide the results as the prediction value. In between them, hidden layers exist where the whole process is carried out.

4.5.7. Adaboost classifier (AB)

AdaBoost classifier also known as Adaptive Boosting is an ensemble boosting classifier which merges various classifiers to improve the prediction accuracy. It follows iterative process which results in better output as compared to other techniques. It focuses on the poor prediction values thus, improve it in other iterations.

4.5.8. Random forest classifier (RFC)

Random Forest Classifier is an ensemble method used in machine learning techniques. It control over-fitting using Bootstrap Aggregator or bagging. The goal of Random Forest Classifier is to combine multiple decision trees from randomly selected subsets to get the final output. It can deal with a large number of information factors without removing variables. It gives appraisals of what factors are significant in the classification.It improves the prediction accuracy by reducing the variance of single tree.

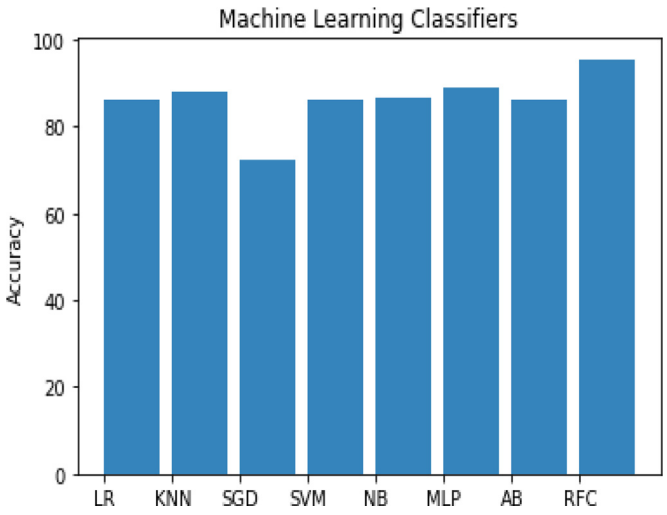

Fig. 12. Comparison to predict accuracy among Machine Learning classifiers for LinkedIn dataset.

4.6. Geo-area based recommender system

Geo-area refers to analysis of geographical location of the organizations that provide job offers. These are programming level administrations that utilize the area information to give helpful recommendation to candidates. Joan Capdevila et al. [19] presented a Geo-SRS recommender system for location oriented using social network data. It uses traveller's reviews on the places they visited earlier and make recommendation to them using similar reviews. The implementation work is carried out on Four square restaurant tips dataset. The system locate them using Geo-map or geographical location map to get their designated place easily. The hybrid filtering technique is utilized in this paper. It merges sentiment analysis and text modeling to get accurate performance of Geo-SRS system. Our work proposes a keen framework that mines social networks to coordinate the best opening for the job searching candidates.

5. Results and implementation

5.1. Analysis of machine learning classifiers for LinkedIn dataset

By using all the above machine learning classifiers in the LinkedIn dataset, we get that Random Forest Classifier results in highest prediction accuracy of 95.58% with highest F1 score of 0.979 as compared to other algorithms. Table 1 represents a comparison table among various machine learning classification algorithms for the LinkedIn dataset.

Fig. 12 represents the graph which compare the accuracies among different machine learning classifier algorithms for LinkedIn dataset. It clearly shows that the Random Forest Classifier (RFC) have the highest accuracy value.

5.2. Use of optimization technique in machine learning classifiers for LinkedIn dataset

Optimization techniques [18] are used in various fields to get the optimum or satisfactory results. It extricates the noisy data that may be formed during creation of model. Optimization is an essential step in the field of machine learning algorithms. It basically minimize the effect of cost function or loss function by providing the appropriate model.These data may results in poor performance of the model which leads to over fitting. To overcome this problem, we have used Stratified K Fold optimization technique for better prediction accuracy of machine learning classifiers. It is a statistical method to evaluate the competency of machine learning models. This technique consists of K that refers to the

Table 1.
Machine Learning classification algorithms for LinkedIn dataset.

Sl. No.	Machine Learning Classifiers	Accuracy	Precision	Recall	F1 Score
1.	Logistic Regression	86.15%	1.0	0.861	0.941
2.	K Nearest Neighbors	87.95%	0.925	0.912	0.910
3.	Stochastic Gradient Decent	72.25%	0.771	0.641	0.708
4.	Support Vector Machines	86.15%	1.0	0.861	0.941
5.	Naïve Bayes	86.74%	0.991	0.871	0.928
6.	Multilayer Perceptron	88.95%	0.999	0.871	0.932
7.	AdaBoost	86.15%	1.0	0.861	0.941
8.	Random Forest Classifier	95.58%	0.997	0.965	0.979

Table 2.
Machine Learning classification algorithms after optimization using stratified K fold in LinkedIn dataset.

Sl. No.	Machine Learning Classifiers	Accuracy	Precision	Recall	F1 Score
1.	Logistic Regression	87.21%	1.0	0.872	0.932
2.	K Nearest Neighbors	94.95%	0.980	0.962	0.971
3.	Stochastic Gradient Decent	64.32%	0.686	0.877	0.770
4.	Support Vector Machines	87.21%	1.0	0.872	0.932
5.	Naïve Bayes	86.59%	0.991	0.872	0.928
6.	Multilayer Perceptron	87.19%	0.999	0.872	0.932
7.	AdaBoost	87.27%	0.999	0.872	0.932
8.	Random Forest	99.78%	1.0	0.997	0.998

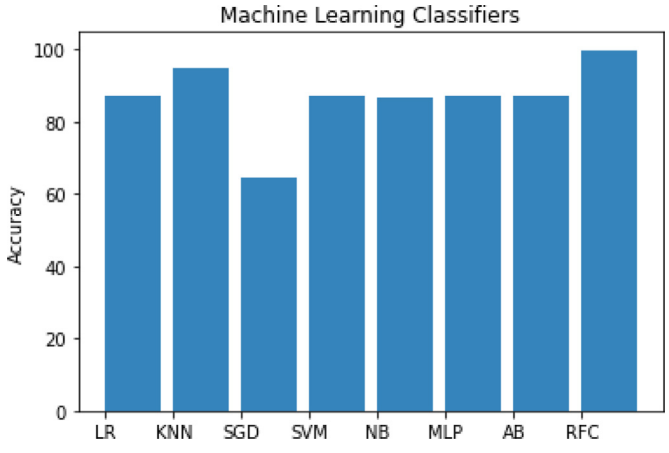

Fig.13. Comparison of prediction accuracy among Machine Learning classifiers using stratified K fold for LinkedIn dataset.

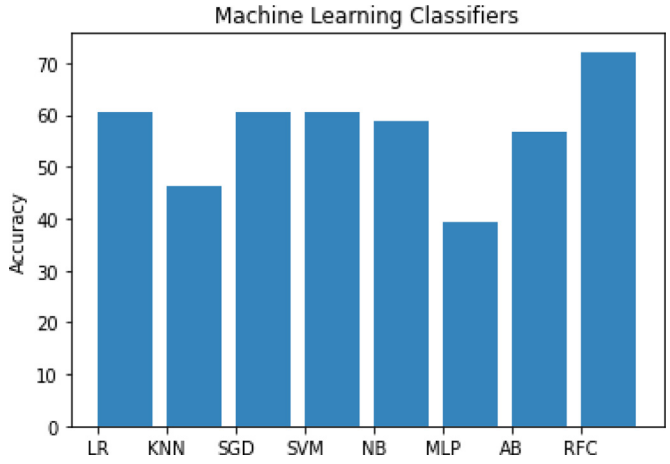

Fig. 14. Comparison to predict accuracy among Machine Learning classifiers for Facebook dataset.

number of cluster that the given dataset may split into. It basically results in less bias as compared to other optimization techniques. Table 2 represents machine learning classification algorithms after optimization using Stratified K Fold in LinkedIn dataset. We get that Random Forest Classifier results in highest prediction accuracy of 99.78% with highest F1 score of 0.998 as when contrasted other algorithms.

Fig. 13.illustrates a barchart for comparison of prediction accuracy among Machine Learning Classifiers using Stratified K Fold for LinkedIn dataset.

5.3. Analysis. of machine learning classifiers for Facebook dataset

To examine that whether the result is valid only up to LinkedIn or not we applied these machine learning classification algorithms to other job hunting website. For Face book dataset, we have used the above machine learning classifiers to predict accuracy. It likewise shows that RFC have most elevated accuracy value of 72.15% with most noteworthy F1 score of 0.735 when contrasted with different classifiers. Table 3 represents a comparison table among various machine learning classification algorithms for the Face book dataset.

Fig. 14. represents the graph which compare the accuracies among different machine learning classifier algorithms for Facebook dataset. It clearly shows that the Random Forest Classifier (RFC) have the highest accuracy value.

5.4. Use of optimization technique in machine learning classifiers for Facebook dataset

Table 4 represents machine learning classification algorithms after optimization using Stratified K Fold in Face book dataset. We get that Random Forest Classifier results in highest prediction accuracy of 99.03% with highest F1 score of 0.998 when contrasted with other algorithms.

Fig. 15 illustrates a barchart for comparison of prediction accuracy among Machine Learning Classifiers using Stratified K Fold for Face book dataset.

With these observations, we have cleared that the result isn't just applicable to LinkedIn dataset but also can work for other job boards. As it shows that Facebook also gave similar result i.e. RFC is better and gives

Table 3.
Machine Learning classification algorithms for Facebook dataset.

Sl. No.	Machine Learning Classifiers	Accuracy	Precision	Recall	F1 Score
1.	Logistic Regression	60.58%	0	0	0
2.	K Nearest Neighbors	46.15%	0.319	0.273	0.243
3.	Stochastic Gradient Decent	60.58%	0	0	0
4.	Support Vector Machines	60.58%	0	0	0
5.	Naïve Bayes	58.65%	0.246	0.428	0.218
6.	Multilayer Perceptron	39.42%	1.0	0.394	0.565
7.	AdaBoost	56.73%	0.415	0.447	0.430
8.	Random Forest Classifier	72.15%	0.488	0.488	0.735

Table 4.
Machine Learning classification algorithms after optimization using stratified K fold for Facebook dataset.

Sl. No.	Machine Learning Classifiers	Accuracy	Precision	Recall	F1 Score
1.	Logistic Regression	70.39%	0	0.872	0.932
2.	K Nearest Neighbors	76.81%	0.628	0.962	0.971
3.	Stochastic Gradient Decent	70.39%	0	0.877	0.770
4.	Support Vector Machines	70.39%	0	0.872	0.932
5.	Naïve Bayes	60.87%	0.067	0.872	0.928
6.	Multilayer Perceptron	45.81%	1.0	0.872	0.932
7.	AdaBoost	74.15%	0.476	0.872	0.932
8.	Random Forest	99.03%	0.994	0.997	0.998

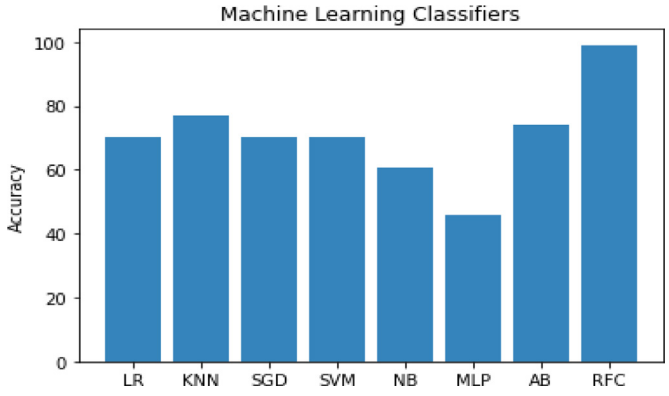

Fig.15. Comparison of prediction accuracy among Machine Learning classifiers using stratified K fold for Facebook dataset.

highest accuracy value when contrasted with other machine learning classifier algorithms.

Hence, we can utilize Random forest classification (RFC) algorithm for recommendation of jobs. This implementation provides the information that RFC can be used by numerous organizations over the globe to give reasonable employments to the aspiring job seekers. These organizations can work on various job boards to filter the candidates and the job offers using RFC as RFC provide better result when contrasted with other machine learning techniques.

5.5. Geo-area based recommender framework for job locations

We have used two most popular social network named as LinkedIn and Face book for our evaluation process. The resultant matches are found by mining the organization's locations from the given datasets. It encourages the candidates to reach their particular employment areas without any problem. The framework recommends the job locations based on organization's database. It defeated the issue of information sparsity. The user area network is scanty because of the restricted visits to areas. Thus, information sparsity happens and it will turn out to be more testing when candidates travel outside their local city. The geo-area based framework contributes the task to many job boards to recommend the aspiring candidates with upcoming employments, events, posts and so forth. Candidates can easily suggested by geo-area recommender framework to reach their respective organization location. Geopandas package is used while processing the data to do geometric operations. Shapely is imported to generate the results. Matplotlib is used to indicate the organization location on the specific maps.Fig. 16. represents the organization's locations from the LinkedIn dataset. It displays various areas of Australia along with its geometry.

The recommender system uses this information to suggest the exact location of the organization using the latitude and longitude of different areas of Australia. The Organization's location for LinkedIn dataset on the world's geographic map is visualized in Fig. 17.

The map displays different organization locations of LinkedIn dataset. It plays a major role in the process of job supply.

The job recommender system takes the organization location from the LinkedIn dataset and suggests to job aspirants those are eligible for the particular job. Hence, job aspirants can easily track the location via map to reach their recommended organization. As the job demand is increasing, the recommender system recommends the exact job that match the candidate's profile along with the organization location. Similarly, the technique is applied in the Face book dataset. It displays various areas of United States along with its geometry. Fig. 18 represents the Organization's locations using Face book dataset.

The Organization's location for LinkedIn dataset on the world's geographic map is visualized in Fig. 19.

The map displays different organization locations of Facebook dataset. Candidates can track the organization locations to reach their organization. The recommendations are carried out through Facebook dataset. This map displays all the possible organization location of United States so that job seekers can easily get their particular point.

6. Conclusion and future work

Recommender framework encourages us to get what we need from the huge measure of data. It recommends the specific item instead of an over-burden of information. As a domain of recommender system, Job recommender system provides opportunities for job seekers by suggesting relevant jobs to them. This framework is utilized by numerous organizations to recommend suitable jobs to the job seekers. It additionally manages the issues of data over-burden. Recommender system gained popularity in recent years due to its success over a huge amount of data. As one of the domain, online recruiting system utilizes the recommender

Sl.No	CITY	LATITUDE	LONGITUDE
1.	Sydney Area	151.20900	-33.86510
2.	Leura	145.61279	-31.84023
3.	Melbourne	144.84479	-37.66371
4.	Queensland	142.70279	-20.91757
5.	New South Wales	145.61279	-31.84023
6.	West Australia	122.80518	-25.76032
7.	Victoria	144.96460	-37.02010
8.	Greeenway	149.06825	-35.41849
9.	South Australia	136.20915	-30.00023
10.	Canberra	145.12346	-31.84023
11.	Birdsville	140.65435	-31.23443
12.	Perth	130.98721	-23.14523
13.	Adelaide	127.23564	-22.13565
14.	Mackey	131.12346	-20.12354
15.	Newcastle	132.12457	-19.12549
16.	Alice Springs	133.12548	-18.13245
17.	The Kimberley	135.54623	-17.35490
18.	Karratha	125.12435	-16.25432
19.	Namburg	137.12346	-25.12345
20.	Brisbane	130.12344	-25.13245

Fig. 16. Organization's location for LinkedIn dataset.

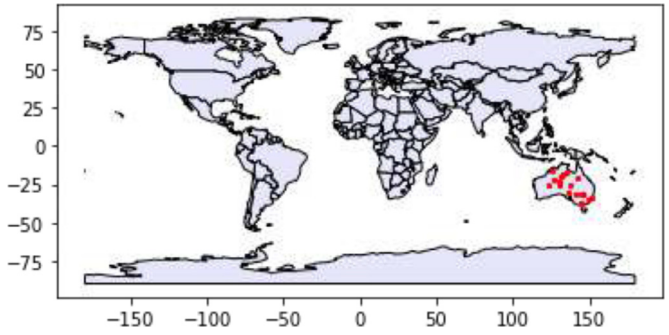

Fig. 17. The Organization's location for LinkedIn dataset on world's geographic map.

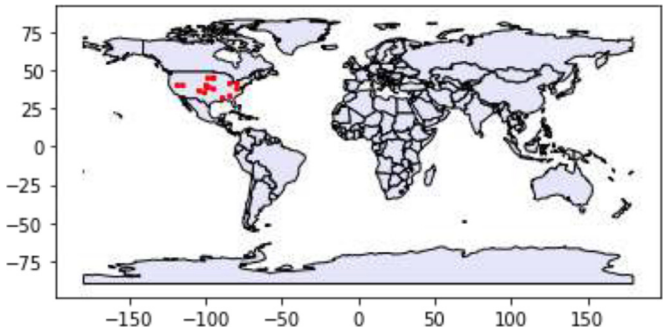

Fig. 19. The Organization's location for Facebook dataset on world's geographic map.

systems by providing suitable jobs to users using the social network user's data. This paper provides a brief detail of various categories of recommender system. Implementation work is done by comparing various machine learning classification algorithms using Python language as a base. The experiment is done on two different job boards. The results are then optimized to get the efficient and accurate value. Promising results shows that Random forest classifier gains highest prediction accuracy with high F1 score when contrasted with other algorithms in

Sl. No.	CITY	LATITUDE	LONGITUDE
1.	Cupertino	-80.03220	38.32300
2.	Mountain View	-105.03630	37.36880
3.	Redmond	-95.03530	45.36880
4.	Round Rock	-85.03650	33.37081
5.	Armonk	-115.03160	40.52010
6.	Santa Clara	-80.65420	42.21360
7.	Palo Alto	-100.02650	40.21980
8.	Menlo Park	-99.05420	39.65210
9.	Seattle	-95.02650	38.0.6540
10.	Georgia	-100.65210	39.32150
11.	Columbus	-99.03650	45.26860
12.	Indiana	-100.95340	36.21540
13.	Michigan	-95.95420	45.65240
14.	Wisconsin	-119.02350	41.03250
15.	San Jose	-90.12340	32.03210

Fig. 18. Organization's location for Facebook dataset.

both the datasets. We have also used geo-area based recommender system that can help the desired candidates to reach the exact location of the organizations they have been recommended for. We would like to expand the work by accomplishing more research on geo-area based recommender framework by giving the applicants the close by areas. This can likewise assist them with tracking the organization areas as indicated by the recommendations.

Declaration of Competing Interest

On behalf of all authors, I (Sthitapragyan Mohanty) declare that we don't have any conflict of interest with any third party or among us.We also declare that this article is not funded by any external agency or any financial organization.

References

[1] F.O. Isinkaye, Y.O. Folajimi, B.A. Ojokoh, Recommendation systems: principles, methods and evaluation, Egypt. Inform. J. 16 (2015) 261–273.
[2] G. Adomavicius, A. Tuzhilin, Toward the next generation of recommender systems: a survey of the state-of-the-art and possible extensions, IEEE Trans. Knowl. Data Eng. 17 (2005) 734–749.
[3] Y. Shuo, Md Korayem, K. AlJadda, T. Grainger, S. Natarajan, Combining content-based and collaborative filtering for job recommendation system: a cost-sensitive Statistical Relational Learning approach, Knowl. Based Syst. 136 (2017) 37–45.
[4] S. Benabderrahmane, N. Mellouli, M. Lamolle, On the predictive analysis of behavioral massive job data using embedded clustering and deep recurrent neural networks, Knowl Based. Syst. 151 (2018) 95–113.
[5] N. Mellouli, S. Benabderrahmane, M. Lamolle, P. Paroubek, Smart4job: a big data framework for intelligent job offers broadcasting using time series forecasting and semantic classification, Int. J. Eng. Sci. Res. 5 (2017).
[6] J. Miao, Y. Fang, H. Xie, J. Chong, M. Meng, User click prediction for personalized job recommendation, World Wide Web 22 (1) (2019) 325–345.
[7] V.D. Priscila, F. Ortega, E. Cobos, R.L. Cabrera, A collaborative filtering approach based on Naïve Bayes classifier, IEEE 7 (2019).
[8] S. Ahmed, M. Hasan, Md N. Hoq, Md A. Adnan, User interaction analysis to recommend suitable jobs in career-oriented social networking sites, in: International Conference on Data and Software Engineering (ICoDSE), IEEE, 2016, pp. 1–6.
[9] S. Guo, F. Alamudun, T. Hammond, RésuMatcher: a personalized résumé-job matching system, Expert Syst. Appl. 60 (2016) 169–182.
[10] M. Diaby, E. Viennet, Taxonomy-based job recommender systems on Facebook and LinkedIn profiles, in: 8thInt.Conf. on Research Challenges in Information Science (RCIS), IEEE, 2014, pp. 1–6.
[11] W. Fan, Y. Ma, Q. Li, Y. He, E. Zhao, J. Tang and D. Yin, "Graph neural networks for social recommendation," https://arxiv.org/abs/1902.07243, 2019.
[12] H. Ma, H. Yang, M.R. Lyu, I. King, SoRec: social recommendation using probabilistic matrix factorization, CIKM (2008) 931–940.
[13] S. Marsland, Machine Learning: an Algorithmic Perspective, CRC Press, 2015.
[14] Kevin P. Murphy, Machine learning: a Probabilistic Perspective, MIT Press, 2012.
[15] Yu-Dong Zhang, et al., Facial emotion recognition based on biorthogonal wavelet entropy, fuzzy support vector machine, and stratified cross validation, IEEE Access 4 (2016) 8375–8385.
[16] P. Sujini, D.N. Vasundhara, A Survey on Framework of Efficient keyword query suggestion on geo-location using document proximity, Int. J. Res. 5 (12) (2018) 3492–3497.
[17] A. Khan, B. Baharudin, L.H. Lee, K. khan, A review of machine learning algorithms for text-documents classification, J. Adv. Inf. Technol. (2010) 4–20.
[18] G.C. Onwubolu, B.V. Babu, New Optimization Techniques in Engineering, 141, .Springer, 2013.
[19] J. Capdevila, M. Arias, A. Arratia, in: GeoSRS: A Hybrid Social Recommender System for Geolocated Area Information Systems, 57, 2016, pp. 111–128.