

# A DECISION TREE WITH FILTER ATTRIBUTE SELECTION MODEL FOR DESIGNING AN AUTOMATED JOB RECOMMENDER SYSTEM FOR CANDIDATE MATCHING THROUGH ONLINE RECRUITMENT

S. KRISHNA KUMAR<sup>1</sup>, DR. E. RAMARAJ<sup>2\*</sup>, DR. S. SANTHOSHKUMAR<sup>3</sup>, DR. P. GEETHA<sup>4</sup>

<sup>1</sup>Research Scholar, Department of Computer Science, Alagappa University, Karaikudi.

<sup>2</sup>Formerly Professor & Head, Department of Computer Science, Alagappa University, Karaikudi.

<sup>3</sup>Assistant Professor, Department of Computer Science, Alagappa University, Karaikudi.

<sup>4</sup>Associate Professor, PG Department of Computer Science, Dr. Umayal Ramanathan college for women, Karaikudi

krishwin25@gmail.com, eramaraj@rediffmail.com, santhoshsundar@yahoo.com, geeth.ganesan@gmail.com

## ABSTRACT

Due to globalization and Advancement in the Technology, the job vendors across the globe search for candidates having some specific talents to fulfill the job vacancy of their companies. The online recruitment system acts as a bridge for connecting the job seekers and job vendors through Internet across the globe. Most of the companies nowadays rely on online job recruitment websites to hire employees for their companies. Due to the lack of proper resume format and difficult in extracting the job-related attributes from the uploaded resume most of the job recruitment websites failed to match the suitable jobs for the registered candidates. This research proposed a Decision Tree with Filter Attribute Selection (DT-FAS) Model for designing a recommender system for online job recruiting environment. Most of the online recruitment websites have complex registration process and it failed to collect the relevant job description and job skills attributes from the employees and recruiters. This research designed a registration form in Google Forms to simplify the registration procedure. The link of the form is send to users through WhatsApp and Emails and the job seekers are allowed to enter their details and the data is collected as Google Spreadsheet. Feature Engineering is done on the collected dataset to select the relevant job matching attributes with the help of filter feature selection techniques such as Info Gain, Chi Square and Tree Based methods. Decision Tree Induction algorithm was implemented on the job seekers data having selected attributes. The job seekers were classified according to the association rules generated from the decision tree and the appropriate job matching their profile was identified. The results analyzed with the performance metrics showed that the decision tree built with the selected attributes of Information Gain method gives best result and correctly identified job matching attributes present in the database.

**Keywords:** *Online Job Recommender System, Filter Feature Selection Techniques, Decision Tree Induction Algorithm.*

## 1. INTRODUCTION

In the technological era most of the companies and academic institutions rely on Online Job Recruitment Websites to recruit new workers for their organization. The Job providers post their vacancy details on the recruitment websites such as naukuri.com, timesjobs.com and the job seekers also register their details in the job providing websites and upload their resume in that websites[1]. The online job portals receive

the uploaded resume and analyze the resume and recommend the suitable job matched for the registered candidate. India is a country having huge human resource and nearly one million of people are entering into the job market every month. In this COVID Pandemic situation most of the companies conduct interviews through online and also provide work from home opportunities. Need for good recruitment system is mandatory

for running the business organization as it coordinates all the recruitment process in a single platform and also reduces the time spent on administration tasks. A good recruitment system should have proper communication to the job seekers via E-mails otherwise the candidates will withdraw from the website suddenly without giving proper explanation. Hiring employees in a quick manner to fulfill the job immediately can have the chance of selecting wrong candidates for a job and it will cause loss to the company. Good job recruitment portals should display the advertisement in an attractive manner in the websites and all the necessary keywords about the job should be present in the advertisement. The recruitment portals should receive feedback from the users and try to improve their job matching performance every year so as to improve their trust from their users. Most of the job seekers don't have a common format for their resume while applying for a job[2]. The online job recruitment portals face many challenges while shortlisting the uploaded resume, because there is a lack of necessary details such as job skills, and domain knowledge in the uploaded resume. Recruiting a suitable person for a particular job is a major challenge faced by the Human Resource department of all companies. The Online portal overcomes these challenges by posting the job vacancy on their websites and increase the recruitment of a suitable candidate across the globe. Thousands of resume were received all over the world for a particular job and it helps the companies to select a right candidate for their job. However the online job recruitment mechanisms also face many challenges such as large competition on increased job searching websites, lack of updatable job post on their websites, large form filling process etc. Due to the increase in the uploaded resume for a job portal system the traditional way of job matching by Boolean search method is not suitable for job matching nowadays. To handle the massive amount of digital data generated by online recruitment portal this research used Machine Learning techniques to analyze the huge data and identified the patterns suitable for job matching. The research contribution includes the following:

- This research proposed a **Decision Tree with Filter Attribute Selection (DT-FAS)** Model for designing a recommender system for online job recruiting environment.
- A Simplified Google form is created to get the relevant data from the job seekers and

hence the complexity in registering with the online recruiting websites was solved.

- Filter Based Feature selection techniques such as Chi Square, Info Gain and Embedded Feature Selection technique called Tree Based Feature Selections were used to extract the relevant job matching attributes from the dataset.
- Decision Tree Algorithm was implemented on the job seekers dataset and patterns of the job seekers were classified to match their desired job.

## 2. LITERATURE REVIEW

Jing Zhao et al[3] presented an Embedded based job matching recommendation system for various vacancy posted on the online job recruitment websites. The author uses Natural Language Processing techniques to extract the words related to job skills, job recruitment and location of the work from the uploaded resume by the job seekers. The embedded system proposed by the author uses deep learning to extract the domain knowledge. The author also used Information Graph method to extract the job skill from the parsed text. The location of the work is identified using the spherical coordinates calculator designed by the author and used for job matching purpose. The job matching recommender system designed by the authors gained attention to job providers and job seekers who are in academia and industry. Ravitha Mishra et al[4] designed a job recommender system that overcome the problem of cold start and scalability issues in online recruitment. The author uses deep semantic structure method to extract the features related to job description and job skills from the uploaded resume. The data is collected from Naukri.com and Carrerbuilder.com and feed forward method is used to extract the text from the resume. The Recurrent Neural Network is used to extract the parsed word into sequence. The Convolutional Neural Network is built from the extracted text and patterns of job required for the posted job is identified. The author used XGBoost model is used to test the performance of the proposed model and the results shows that the proposed method gives better job recommendations. D.Mhamdi et al[5] presented a k-means clustering based job recommendation system to match the designed job for the job seekers. The authors collect the resume form the online recruitment

websites and parse the text in the resume with Natural Language Processing Techniques. K-Means clustering is applied to the dataset and the job seekers applying for a particular job are clustered. The category of job seekers is summarized based on the job clusters they belong and job recommendation is done based on the similarity of the job skills they have. Yeonjae Jing et al[6] proposed a text mining approach that is used to analyze the job satisfaction level of employees working through online mode. The authors collected data from 35,063 online employees by posting a questionnaire in the jobplanet.co.kr website. The author designs a module to handle the curse of dimensionality and out of dictionary problem that arise while analyzing the text document for analytics purpose. The author’s proposed model first does spacing correction by using an Iterative Mechanism and extract the nouns. The nouns extracted were tested whether the words are dictionary words or out of dictionary words using POS tagging and NLTK collocation analysis method. Pradeep Kumar Roy et al[7] proposed a

Machine Learning based automated resume classification model that correctly matches the job suitable for the job seekers. The features related to job matching such as skills and job description were extracted and the candidates are ranked using context based ranking method. The machine learning classifiers such as random forest, SVM, Naïve Bayes were used to classify the database and the suitable job recommendation was done to the candidates. Bushra Ramzan et al[8] proposed a collaborative filtering approach for selection of suitable hotel location and reservation of accommodation for travellers. The authors collect huge volume of datasets that containing textual data related to the quality of the hotel like review and comments. The author also collects numerical data such as ratings and likes by the consumer. Text Mining is done with Natural Language Processing method a feature matrix is formed. The author used Casandra and Hadoop to store the huge volume of datasets and computed the polarity scores and recommends the hotels suitable for travellers.

**1. Proposed Decision Tree with Filter Attribute Selection (DT-FAS) Model for Online Job Recommendation System.**

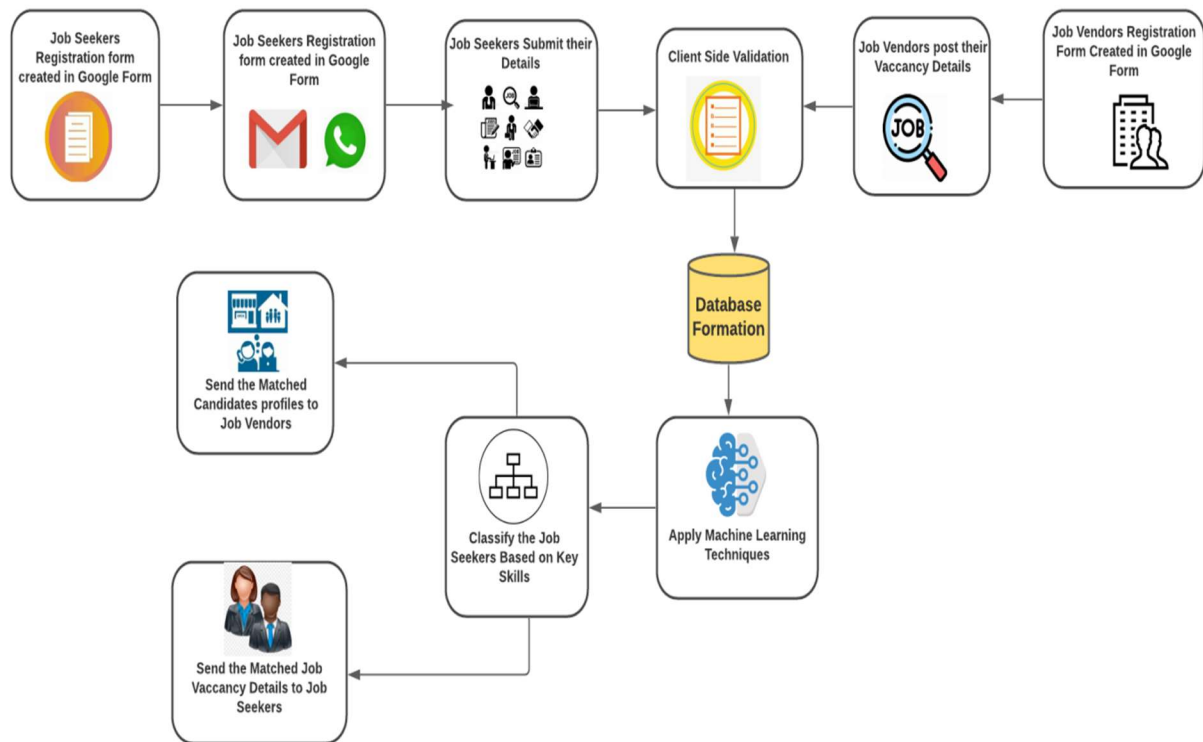


Figure 1: Overall Workflow Of The Proposed Framework

The overall workflow of the proposed Decision Tree with Filter Attribute Selection(DT-FAS) Model for designing a Recommender System is shown above in Figure 1. Here a Google Form is created with the following link (<https://forms.gle/9Nkzv2WUR6dC4rxq6>) and sends to Employees and Job Seekers through WhatsApp Groups and E-mails. The College Students studying final year UG and Post Graduate were also asked to register their details through this Google form. The Google form is created in such a manner that it has the ability to validate the form from client side before submitting. The data entered by the user is stored in a google spreadsheet and finally the database retrieved from the Google drive and stored in the local system for further use[9]. While implementing machine learning in real life application there arises a lot of confusion to the researchers to choose which techniques to use. The second problem concerns with the

performance of the machine learning algorithms used. While the dataset used for training the model contains too many attributes it leads to over fitting. If the size of the training attributes contains very low number of attributes or low input records it tends to under fitting. The impurities present in the dataset such as missing values or redundant values decreases the performance of the machine learning classifier. Feature Engineering is the only solution to improve the performance of the classifier[10]. When the input data provided to the machine learning model is pure and if it is in suitable format for the selected algorithm then the performance of the algorithm will be increased and it will identify the patterns present in the database efficiently. The Machine Learning Implementation framework of the proposed Decision Tree with Filter Attribute Selection Model is shown below in Figure 2.

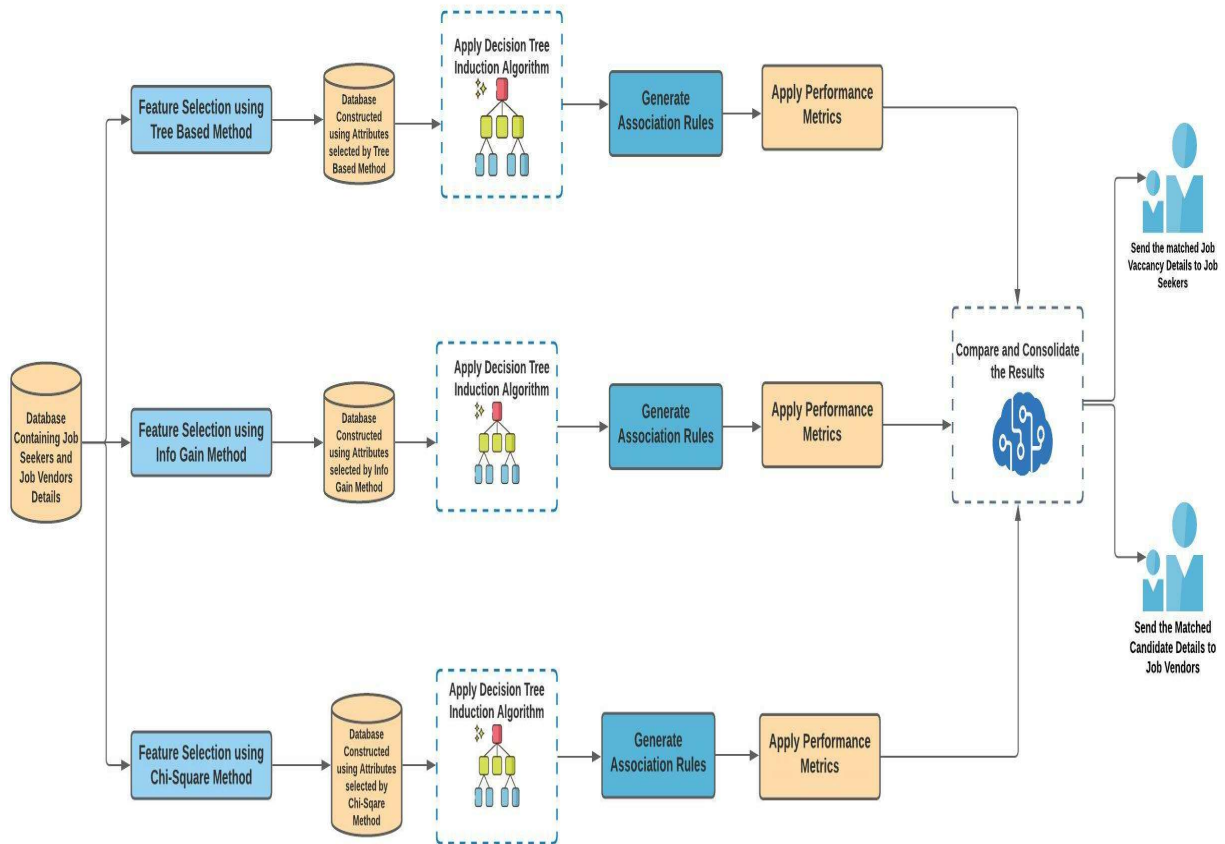


Figure 2: Architecture Of The Proposed Decision Tree

with Filter Based Attribute Selection Model

The proposed machine learning framework uses feature selection techniques such as Tree Based,

Chi Square and Info Gain feature selection method for selecting the relevant job selection

attributes from the database. The reason for selecting these three methods is they select the best attributes with considering the machine learning technique which is going to be implemented with the selected attributes. They treat all the input variables with equal importance and compute fitness score and select the best attributes that improves the computation speed and increase the accuracy of the machine learning algorithms. The **Tree Based** Feature Selection method work as same as the Random forest algorithm works and select the top k attributes from the input variables. Random forest is a throng of decision trees where every single decision tree is generated from a subset of the whole dataset. A dataset is split into subsets by the bootstrap aggregation method and each subset is created as a decision tree. The top k node in the tree is selected as the best attributes by the Tree Based Method. The **Chi Square** method calculates the relationship between the input

variables with respect to the target variable and calculates the Chi Square value. If the Alternate Hypothesis is accepted then the input attributes is selected for consideration otherwise if the Null Hypothesis is accepted then the input attributes is removed from the list. The Info Gain method calculates Information obtained from each input attributes which tells the relationship with the target attributes and rank the attributes based on the Information obtained and the top k attributes are then selected by this method. The Decision Tree was then built individually using the selected attributes of the feature selection methods. Association rules related to job matching is extracted from the decision tree and the classification of job seekers related to their job skills were identified by the proposed algorithms. The Pseudo code of the proposed algorithm is given below in Table 1.

Table 1: Pseudo Code For The Proposed Model

<p><b>Pseudo Code for DT-FASModel</b>  <b>Input:</b> A Dataset D, containing features related to Online Job Recruitment  <b>Global Variables:</b>  N-number of records in the dataset; X-number of attributes in the dataset, y-Target Attribute (Variety of Job), FS-Feature Selection, TB-Tree Based, IG-Information Gain Method, Chi-Chi Square Method.  <b>Output:</b>Decision Tree constructed with Job Matching Attributes  <b>Feature Selection Procedure:</b>  1. If(FS==Tree Based) { //k- set the number of attributes to be selected  <b>for each</b> Attribute i ∈ Xi in D {  <b>while</b>(i&lt;k){  a) Info(D)=<math>\sum_{i=1}^m p_i \log_2 p_i</math>.  //Compute the impurity for each input attribute  b) Rank the input attributes based on impurity score  c) Construct decision tree with highest rank attribute as root node  d) Select the top k attributes from the tree  e) Store the selected attributes in set S1 } }  2. If(FS==Chi) {  <b>for each</b> Attribute i ∈ Xi in D {</p>
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<p>a) <math>X^2 = \sum \frac{(Observed\ Value - Expected\ Value)^2}{Expected\ Value}</math>  //Compute Chi Square value for all input attribute  b) Rank the input attributes based on chi square value.  c) Select the top k attributes from the tree  d) Store the selected attributes in set S2 } }  3. If(FS==IG) { //k- set the number of attributes to be selected  <b>for each</b> Attribute i ∈ Xi in D {  <b>while</b>(i&lt;k){  Info(D)=<math>\sum_{i=1}^m p_i \log_2 p_i</math>. //Compute the impurity for each input attribute  If(i==Info<sub>max</sub>) {Remove i from list Xi}  Store the selected attributes in set S3 } }  4. If use Decision Tree {  <b>for each</b> Attribute i ∈ Xi in D<sub>new</sub> {  <b>do</b>{ Split Info(D<sub>new</sub>)=<math>\sum_{j=1}^v \frac{[D_j]}{[D]} \times \log_2 \left( \frac{D_j}{D} \right)</math>  Gain Ratio(A)=<math>\frac{Gain(A)}{Split\ Info(A)}</math>  If(Xi==Max Gain Ratio) {  Root node==Xi }  <b>while</b>(Xi==∅); }</p>
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#### 4. EXPERIMENTAL RESULTS

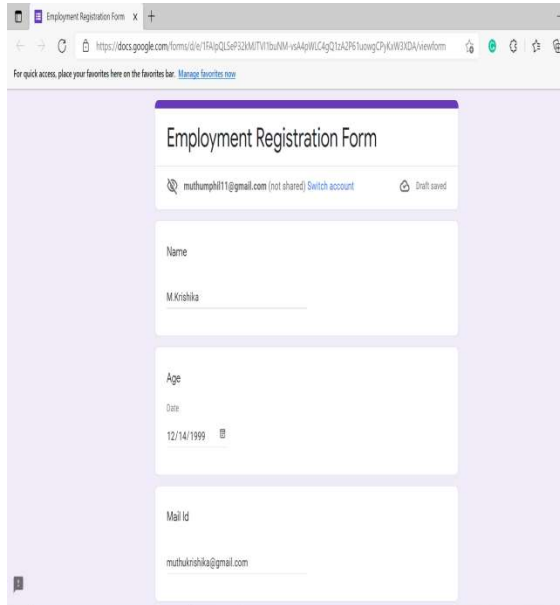


Figure 3: Google Form Created For Data Collection



Figure 4: Details Of The Responses Received Form Job Seekers

The data needed for this study is collected through Google Form and sent through WhatsApp and E-mail to the job seekers. Totally 4300 job seekers registered with us and among them 2356 respondents were female and 1944 were male. The dataset contains totally 18 attributes and the details of the attributes were gender, education details such as board of the study during 10<sup>th</sup> and 12<sup>th</sup>, courses studied in under graduate and post graduate etc. The skills needed for the applied post were collected and they include technical language known, database known to them and operating system which they are familiar etc. The certification course studied apart from the graduation also received from the user. From the dataset 17 attributes were treated as input attributes and Job Category containing 10 input values is treated as the target attributes. All the attributes in the dataset were completely categorical attributes and they were converted to

numerical using LabelEncoder and OneHotEncoder present in the sklearn.preprocessing library in python. The database after preprocessing was converted into 125 attributes and then machine learning techniques were implemented in the preprocessed dataset.

#### Results of the Various Feature Selection Techniques in the Proposed Model

The first method used in this proposed model was Tree Based Feature selection technique. It was implemented using the sklearn.ensemblelibrary present in python. TheExtraTreesClassifiermethod is used to extract the important attributes present in the database. The model was trained to select the top 50 attributes and the results of the tree based model are given below in Figure 5.



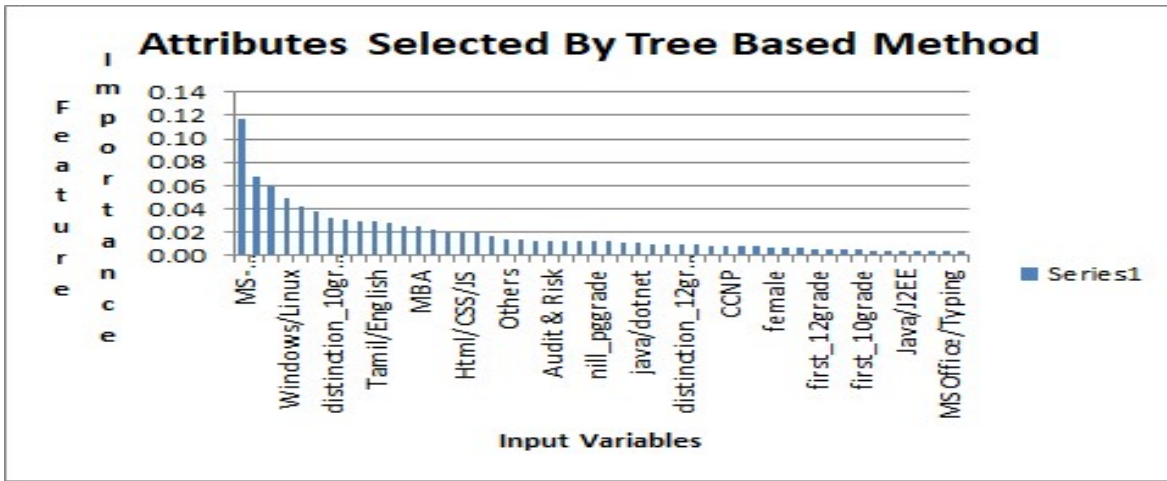


Figure 5: Attributes Selected By Tree Based

Method

The second method is the Chi Square feature selection technique and it is implemented using chi2 method present in the sklearn.feature\_selection library. The chi2 functions returns two values as output one is the

F-score value and the other is the P value. Here for this study the attributes are selected based on the F-score value and the selected attributes are shown in Figure 6.

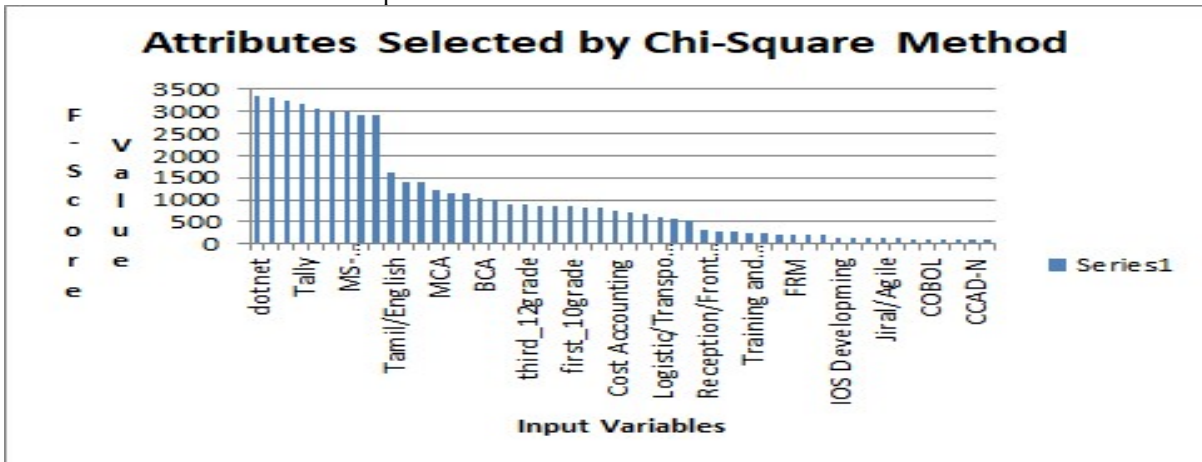


Figure 6: Attributes Selected By Chi-Square Method

The third feature selection method used in this study is Info Gain method and it was implemented using the mutual\_info\_classif method present in the sklearn.feature\_selection library of python.

The top 50 attributes from the 125 input variables were extracted using the SelectKBest method present in the sklearn.feature\_selection method and the results were given below in Figure 7.

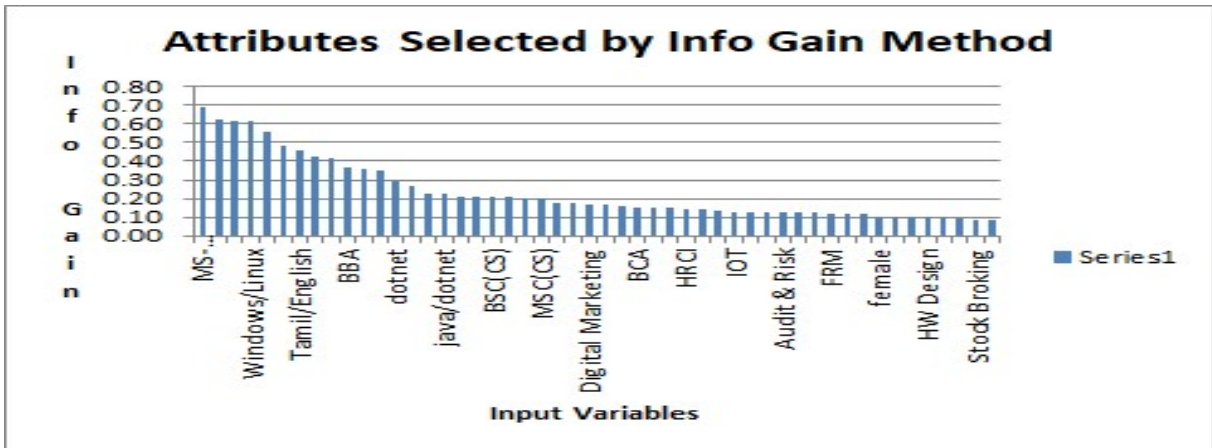


Figure 7: Attributes Selected By Info Gain Method

4.1 Results for the Decision Tree Induction  
Algorithm for Job Seekers Datasets

The job seekers dataset containing 4300 records is divided into 2866 records as training set and 1434 records as testing set and the Decision Induction Algorithm was implemented using DecisionTreeClassifier method present in the

sklearn.tree library in python. Entropy is used as the Attribute selection measure to select the best node from the dataset. The decision tree was built using the job seekers dataset by having at least 50 tuples in a leaf and the constructed decision tree constructed for attributes selected by Info Gain feature selection method is given below in graphical format in Figure 8.

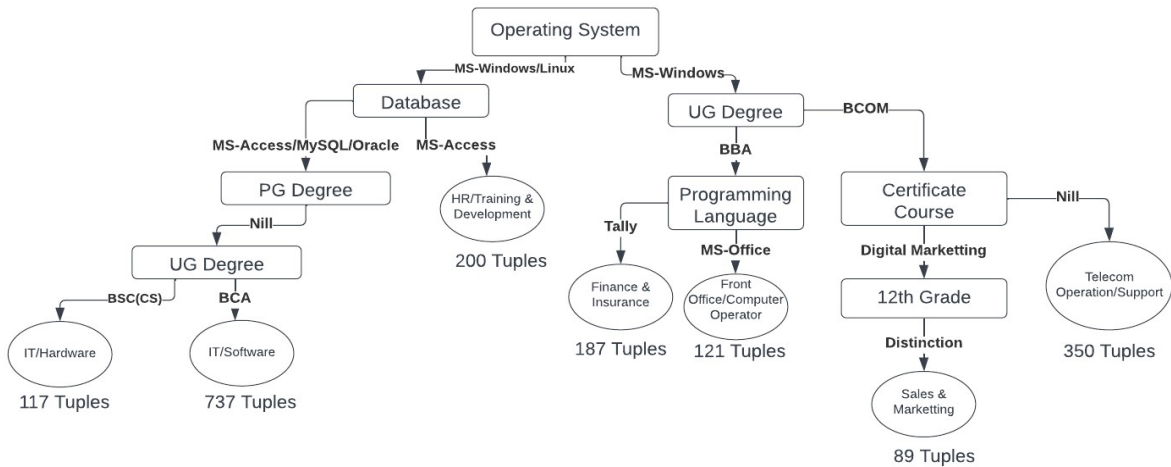


Figure 8: A Branch Of Decision Tree Constructed For Job Seekers Dataset Using Information Gain Selected Attributes  
The Association Rules generated for the constructed decision tree is given below in Table 2.

Table 2: Association Rules Generated From The Decision Tree For The Info Gain Attributes Dataset

R1: IF(Operating System=Ms-Windows/Linux)^(Database=MS-Access/MySQL/Oracle)^(PG Degree=Nil)^(UG Degree=BSC(CS))→(Job Category=IT/Hardware)(117 Tuples).
R2: IF(Operating System=Ms-Windows/Linux)^(Database=MS-Access/MySQL/Oracle)^(PG Degree=Nil)^(UG Degree=BSC(CS))→(Job Category=IT/Software)(737 Tuples).
R3: IF(Operating System=Ms-Windows/Linux)^(Database=MS-Access)→(Job Category=HR Training and Development)(200 Tuples).
R4: IF(Operating System=MS-Windows)^(UG Degree=BBA)^(Programming Language=Tally)→(Job Category=Finance & Insurance)(187 Tuples).

Likewise 23 rules were extracted from the decision constructed using the job seekers dataset.



The same procedure is followed to build the decision tree for the dataset constructed with attributes selected using Chi Square feature

selection method and the decision tree build for the Chi Square dataset is given below in Figure 9.

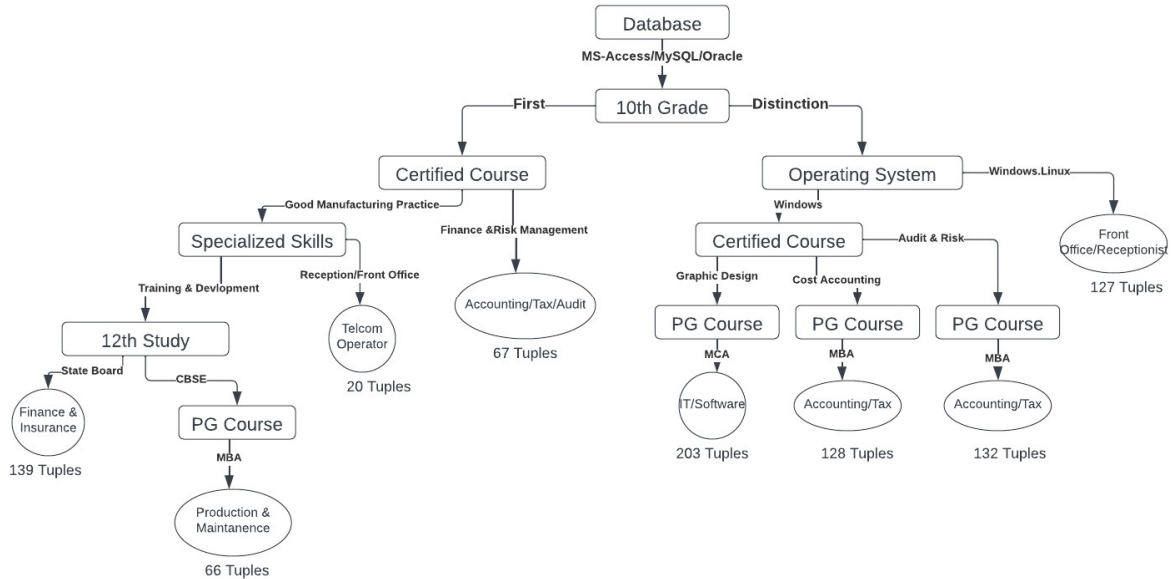


Figure 9: A Branch of Decision Tree Constructed for Job Seekers Dataset using Chi Square Attribute Selection Method

The association rules generated for the decision tree is given in Table 3.

Table 3: Association Rules Generated For The Chi Square Decision Tree

<p>R1:If(Database= MS-Access/MySQL/Oracle)^(10<sup>th</sup> grade=First)^(Certified Course=Good Manufacturing Practice)^(Specialized skills=Training and Development)^(12<sup>th</sup> board=state)-&gt;(Job Category=Finance and Insurance)(139 Tuples).</p> <p>R2:If(Database= MS-Access/MySQL/Oracle)^(10<sup>th</sup> grade=First)^(Certified Course=Good Manufacturing Practice)^(Specialized skills=Training and Development)^(12<sup>th</sup> board=CBSE)^(PG Course=MBA)-&gt;(Job Category=Production and Maintenance)(66 Tuples).</p> <p>R3:If(Database= MS-Access/MySQL/Oracle)^(10<sup>th</sup> grade=First)^(Certified Course=Finance &amp; Risk Management)-&gt;(Job Category=Accounting/Tax/Audit)(67 Tuples).</p> <p>Likewise 15 rules were extracted from the decision constructed using the job seekers dataset.</p>
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The decision build using the tree based feature

selection method is given in Figure 10.

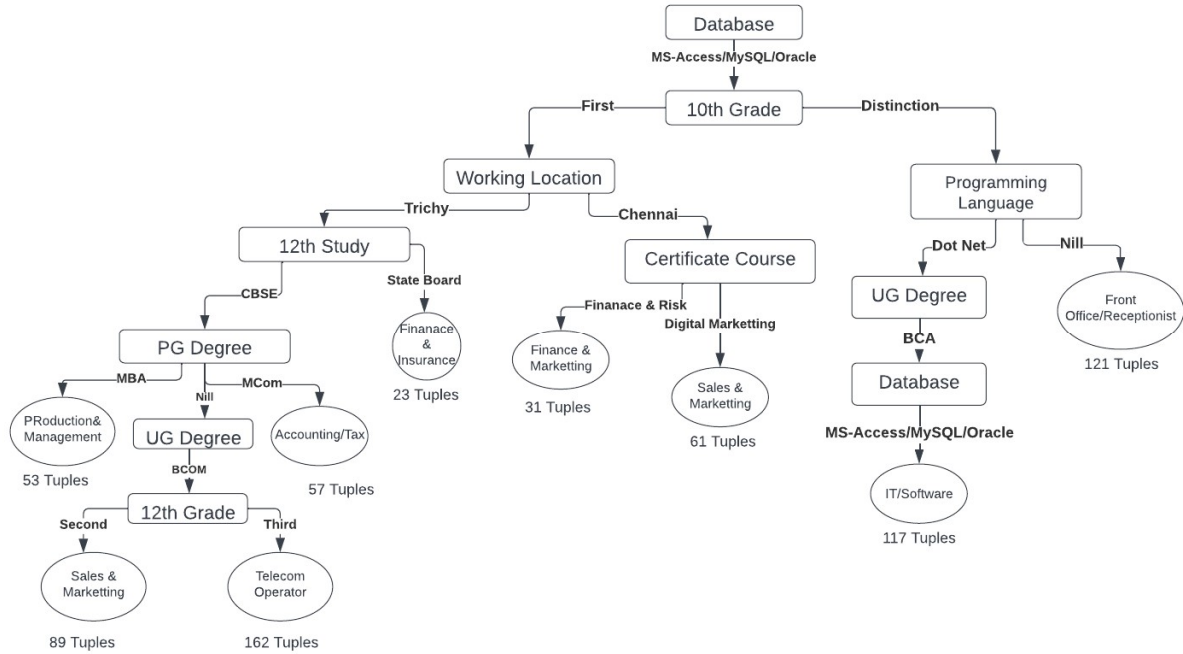


Figure 10: A Branch of Decision Tree Constructed for Jobseekers dataset by Tree Based Feature Selection Method

The association rules extracted from the tree based feature selection method is given in Table 4.

Table 4: Association Rules Generated For The Decision Tree Of Tree Based Attribute Selection Method

R1:If(database=MS-Access/MySQL)^(10 <sup>th</sup> grade=Distinction)^(Desired workplace=Trichy)^(12 <sup>th</sup> board=CBSE)^(PG Degree=MBA)->(Job Category=Production & Management)(53 Tuples).
R2:If(database=MS-Access/MySQL)^(10 <sup>th</sup> grade=Distinction)^(Desired workplace=Trichy)^(12 <sup>th</sup> board=CBSE)^(PG Degree=Nil)^(UG Degree=BCOM)^(12 <sup>th</sup> Grade=Second)->(Job Category=Sales & Marketing)(89 Tuples).
R3:If(database=MS-Access/MySQL)^(10 <sup>th</sup> grade=Distinction)^(Desired workplace=Trichy)^(12 <sup>th</sup> board=CBSE)^(PG Degree=Nil)^(UG Degree=BCOM)^(12 <sup>th</sup> Grade=Third)->(Job Category=Telecom Operator)(162 Tuples).

Likewise 13 rules were spawned from the Decision Tree

The performance of the model was measured using the performance metrics of the classifier and the results were tabulated below in Table 5 for Training sets.

Table 5: Performance Of The Training Set In Job Seekers Dataset

	DT(C4.5)	DT-Chi	DT-IG	DT-TB
Recall	0.890	0.784	<b>0.980</b>	0.973
Specificity	0.995	0.989	<b>0.999</b>	0.999
Precision	0.933	0.787	<b>0.982</b>	0.980
Negative Predicted Value	0.955	0.989	<b>0.999</b>	0.999
False Positive Rate	0.005	0.011	<b>0.001</b>	0.001
False Negative Rate	0.110	0.216	<b>0.020</b>	0.027
False Discovery Rate	0.067	0.112	<b>0.018</b>	0.020
Accuracy	0.970	0.979	<b>0.998</b>	0.998
Error Rate	0.03	0.021	<b>0.002</b>	0.002
F-Score	0.881	0.768	<b>0.979</b>	0.974

The performance of the Decision Tree constructed using the Job Seekers testing dataset is given below in Table 6.

Table 6: Performance of the Testing Set in Job Seekers Dataset

	DT(C4.5)	DT-Chi	DT-IG	DT-TB
Recall	0.892	0.779	<b>0.987</b>	0.972
Specificity	1.150	0.982	<b>0.999</b>	1.005
Precision	0.880	0.836	<b>0.988</b>	0.979
Negative Predicted Value	0.995	0.983	<b>0.899</b>	0.998
False Positive Rate	-0.150	0.018	<b>0.001</b>	0.006
False Negative Rate	0.108	0.221	<b>0.013</b>	0.028
False Discovery Rate	0.120	0.064	<b>0.012</b>	0.021
Accuracy	0.965	0.968	<b>0.998</b>	0.995
Error Rate	0.035	0.032	<b>0.002</b>	0.005
F-Score	0.661	0.506	<b>0.973</b>	0.934

From the above Table 5, it is clear that the decision tree constructed using the attributes selected by both Information Gain and Tree Based feature selection methods classifies the data with high accuracy of 0.998 and produce low error rate of 0.002. Even though these two performs same and produce same accuracy, the Decision tree constructed using Information Gain gives best result when considering the remaining performance metrics such as Recall, Precision etc. While comparing the results of the testing set

given in Table 6, it is clear that the decision tree constructed with Information Gain Attributes performance best and give better result while comparing the rest of the feature selection measures. It is recommended to use Information Gain feature selection method for feature engineering purpose for constructing the decision tree for decision tree having real time datasets. The confusion matrix for the Decision Tree constructed using Information Gain Attribute selection method is given below in Figure 11.

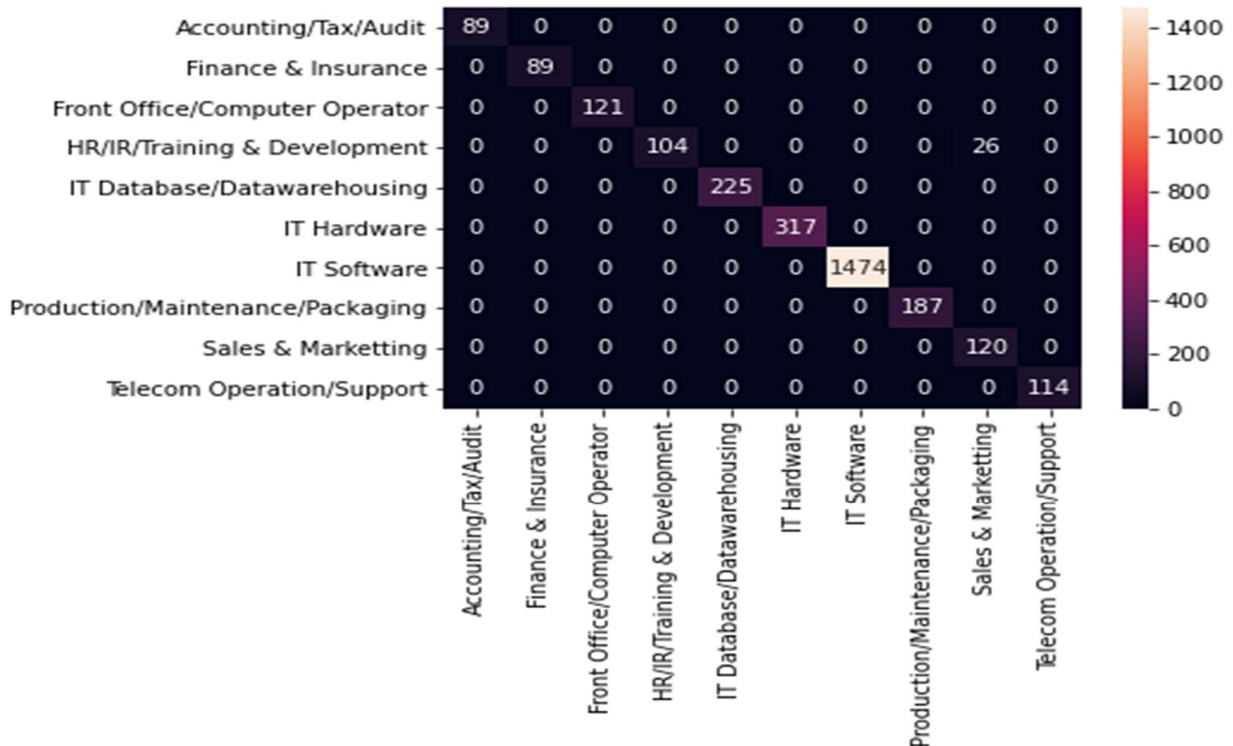


Figure 11: Confusion Matrix For Training Set Constructed Using Information Gain Attribute Selection Measure

## 5. RECOMMENDATIONS FOR JOB SEEKERS

From the knowledge extracted from the decision tree says that the candidates who poses MSC(CS), MCA degree and are fresher it is recommended to select the jobs like Database Administrator and Data warehousing professions. At the same time if the post graduate students has some finished some certified courses like Graphics and Animation Design and also having some technical language skills like otnet, python and java they are recommended for jobs related to software profession in IT industry. For the candidate who don't have a post graduate degree and only having under graduate non computer science degrees such as BBA, BCom they are recommended for Front Office, Telecom Operator Jobs. If the under graduate students having typing skills with basic computer knowledge they are recommended for data entry jobs. The post graduate students who finished MBA and also having specialized skills such as Human Resource certifications are recommended for HR/IR/Training & Development related jobs. The post graduate MCom students who are having specialized skills such as Accounting and Auditing skills were correctly identified by the recommender system and are classified under jobs related Accounting/Tax/Audit jobs. The recommender system also classifies the candidates who have under graduate degree alone and don't have any computer knowledge to Sales & Marketing and Medical Representative Jobs.

## 6. Conclusion

This paper proposed a machine learning model called Decision Tree with Filter Attribute Selection (DT-FAS) Model for Online Job Recommendation System and it overcomes the problem of analyzing the collected job seekers data by traditional Boolean Search method in online recruitment environment. The feature selection techniques used to extract the features related to job matching performs well in identifying the patterns related for job recommendations in the online environment. Among the three feature selection methods used, it is proved that the Decision Tree built using the Information Gain feature selection method performs well while comparing the remaining methods. This paper also suggests various recommendations for job seekers that correctly match their profile. Thus the proposed machine learning model is also helpful for job vendors in

selecting a suitable candidate for their vacancy post and reduces their burden in Human Resource Management in the company.

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