

Decision Support Systems for Entrance Examinations using Bloom's Taxonomy and Support Vector Machines

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Abstract

Admissions to post graduate courses in Karnataka, especially the MCA courses in many government colleges happen through an entrance examination. This entrance examination is being attempted by close to 7000 candidates every year. Students in the final year of degree programmes like B.Sc, BCA, B.Com are eligible to take up this examination. The work in this research paper is an effort to investigate how effectively the question paper of this examination is testing the aptitude of the potential candidates. In this direction, an attempt is being made in order to study the aptitude of the undergraduate students. Standard benchmarks have been evolved by the researchers to evaluate the aptitude of the students. The results of the candidates in the entrance examination over the past 12 years have been studied. Definite patterns of scoring in these examinations have been observed as a result of which, the following research question was posed for the current research work. "Does the Post-Graduation examination test the aptitude of the candidates, if so, to what extent?"

The research work considers the analysis of extensive sets of data sets across the results of the MC Aentrance examinations. Bloom's taxonomy of verbs is employed to classify the questions and support vector machines are being used to identify clusters of students of similar aptitudes. Control group of students are given a variety of questions to justify the aptitude levels formed. This work can be used to generate blue prints of question papers across any of entrance examination which follow the same pattern.

Keywords: Educational data mining, Bloom's taxonomy, Support vector machines, Concept hierarchy, Blue prints

1.0 Introduction

In the context of the current research work done, the entrance examination of the MCA course has a question paper which the researchers feel is not a balanced one. A study of the results of the candidates in their undergraduate examinations in some sample colleges across Karnataka show that the aptitudes of the candidates stands at all the levels. One can easily spot clusters of candidates in the "Top Scoring",

"Average" and "Below average" zones of aptitude. The results of the candidates at their undergraduate examinations from the past 12 years has been examined and definite scoring patterns have been observed. Candidates show different levels of aptitude in related areas of computer science as well as areas which are not so related. A candidate in the "higher aptitude" group in one topic group may or may not be at the same level of aptitude in another topic group.

With this focus in mind, the current work tries to map the aptitude that is getting tested in the entrance examination with the actual aptitude of the candidates. The results of the

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undergraduate examinations is taken as an indicator of the potential aptitude of the candidates. The existing set of questions in the undergraduate examinations are assigned a ranking based on Bloom's taxonomy of verbs. Each level of the Bloom's taxonomy of verbs signifies a certain level of cognition level and that is being used to assign the ranking of the questions. By close examination and studying the pattern of the question papers of the undergraduate examinations it has been deduced that the questions confirm to at the most the fourth level of Bloom's taxonomy, which is, "Analyze". The questions in these examinations are descriptive questions and they are used to benchmark the aptitude level of the candidates and to know their overall comprehension of the topics.

The next step taken is to create a control group of students, and to administer them questions. This group has been created by choosing the candidates in the final year of undergraduate courses which meet the eligibility criteria for taking up the entrance examinations, mainly from BCA and B.Sc with Computer Science as one of the subjects. The tests administered to this group are mostly multiple-choice questions because the actual entrance examination for MCA is based on multiple choice questions. Again here, Bloom's taxonomy of verbs is used to frame the questions and the level is kept at the fourth level. These tests further validate the aptitude level as measured by the researcher's methodology. Further, the questions in the entrance examination are assigned rankings based on Bloom's taxonomy of verbs. The results of the candidates in this entrance examination is analyzed. For the analysis support vector machines are employed. By this analysis, clusters of candidates with the same or similar levels of aptitudes are established. By comparing the performance of these clusters of the candidates, decision support system is framed which is going to aid the formation of question papers, based on the aptitude level of the candidates.

2.0 Related Literature

Bloom's taxonomy of verbs is used in many areas of education. Bloom's taxonomy can assist in developing assessments by helping to matching the course learning objectives to any given level of hierarchy¹¹. Bloom's taxonomy is used for writing effective learning objectives in education¹³. Bloom's taxonomy has been used in formulating assessment questions¹⁴. Bloom's taxonomy has been employed in generating computer based appraisal methods of critical thinking, which assesses the subjective co-operation of the students¹⁵. Bloom's taxonomy has been used in preparing online question paper with questions which meet programme objectives¹⁶. Support Vector Machines have been used to

improve the prediction of student performance¹⁷. Support Vector Machines have been used in¹⁸ to predict the degree completion probability of students. Support Vector Machines have been used in³ to classify students as belonging to several aptitude levels. Support Vector Machines have been used in⁶ to determine the possible difference in the student performance when comparing CBT to identical PPT test mode and also to investigate the malpractices involved in both the test modes. Decision Support Systems have been used in² to suggest suitable courses to be selected by prospective student based on their academic ability. Decision Support Systems have been developed for improving the school quality by performing data driven decisions based on student data.

3.0 Research Problem

The entrance examination for the MCA course has got a definite pattern of questions. The question paper does not seem to test the aptitude of the potential candidates to the extent that should be tested. This entrance examination is a gateway to a Post-Graduate course and given the current pattern of the questions, the chances of candidates with lesser aptitude getting admission to the course are more. Thus, the quality of the student input to the course might suffer. The current work takes it up as a problem to enquire what is the actual aptitude of the potential candidates and what exactly is the aptitude that is getting tested in the entrance examination.

4.0 Research Objective

The main objective of the current research work is to enquire as to whether the entrance examination is testing the aptitude of the potential candidates in the right measure. In doing so, a second objective is to determine what is the aptitude level of the potential candidates. The current work tries answer the research question – "Is the entrance examination testing the aptitude of the candidates correctly, if so to what extent?". Once the aptitude level of the candidates is determined, the potential aptitude and the type of questions to be set is mapped together. The final objective is to evolve a Decision Support System that will assist the examiner to set the questions that are relevant to clusters of candidates, in terms of their aptitude level. All through the work, Bloom's taxonomy is used as an instrument to ascertain the cognition level of the candidates by measuring the aptitude levels that the questions are going to test. Support Vector Machines are used as a methodology for classification related issues involved in the entire process of study.

5.0 Data and Pre-Processing

The data used for the analysis is mainly consisting of three sections. (1) The data containing the results of the candidates in the entrance examination to MCA courses, being conducted mainly by the government body KEA. This is obtained from the public domain and results of the past 12 years of examinations have been used in the analysis. The questions in these question papers are multiple choice-based questions with no negative marking. They question papers consists of questions on some computer science topics such as data structures, number systems, programming languages, rdbms, and many questions testing analytical ability, English language expertise and so on. (2) The results of candidates in the undergraduate examinations from the past 12 years of examinations. The results of all computer science subjects from the three years of degree programmes such as BCA and B.Sc with Computer Science have been taken. (3) The test set administered to the control groups and the results obtained from these tests. The control group consisted of students from many colleges across Karnataka and the questions in these tests consisted of both multiple-choice questions and descriptive questions.

The results have been compiled into excel sheets containing many fields, of which the most important fields are the fields course, subject, marks scored. The other fields have been deleted and not included in the analysis and some of these are the candidate name, the roll number etc. The results stored in the excel files have been further processed to contain coursewise marks, subject wise marks, coursewise and subject wise marks and so on. The questions in all the three sets of data have been ranked using Bloom's taxonomy and the ranking information is maintained in separate excel files, This information will be used at a later stage of the analysis, integrating them with the results in suitable ways.

6.0 Brief Description of The Software Used

For the analysis of the data containing the results of the entrance examination, the neural network library in R is used. These libraries are used to get the clusters of candidates and identifying patterns of scoring in these examinations. For analysis involving the other two result sets, that is, the results of the undergraduate examinations and the results of tests administered to the control groups, the scikit-learn library in Python is used. This library implements support vector machines in Python. For generating the graphs depicting the clusters of candidates, the matplotlib library in Python is made use of. Python version 3 and PyCharm editor are being used for the programming involved.

6.1 A Brief Description of Support Vector Machines

SVM, stands for Support Vector Machines – these are a set of supervised learning models used in machine learning for analyzing data. SVM are used primarily as analysis models for classification and regression. SVM provide a means of providing a hyperplane to separate a set of data points into two distinct classes. The hyperplane is the separator, at which the distance between data points of distinction is the maximum. If the number of features used to classify the data points is two, the hyperplane is a line, if the number of features is three, the hyperplane is a two-dimensional plane and successively the hyperplane could become a 3, n-dimensional separator depending on the number of features used for classification. SVM uses specialized “kernels” in order to classify data points and there are many kind of kernels which can be used depending on the dimensions of data and also the distribution involved. Some common kernels available are sigmoid, linear, radial basis and so on.

7.0 Analysis

The analysis of data has three phases. In the first phase the data of the results of the candidates in the undergraduate examinations is taken up. Here, the computer science related subjects are considered and the results have been analysed. Questions in these examinations are mainly descriptive questions. First of all, the Bloom's taxonomy of verbs is used to ascertain the level of cognition that the questions are testing and accordingly the questions are assigned a “concept ranking”, with values 1,2, 3....6. These 6 levels of ranking specify the weightage of the concepts that are being tested and correspond to the respective levels of cognition as specified by Bloom's taxonomy. Concept rank of 1 corresponds to the level 1 of cognition as specified by Bloom's taxonomy, and so do the higher levels to the respective equivalents. The questions are assigned topic wise in particular subject. For example, if data structures is considered as a complete subject in say, the second year of undergraduation, then the related topics in it such as sorting and searching algorithms becomes one group, linear data structures such as arrays, stacks, queues and linked lists will become another group. So, the questions in each such group are going to be assigned a certain concept ranking taking into account the cognition levels in the corresponding levels as defined in Bloom's taxonomy.

Once such clusters of questions are going to be defined, the next step is to consider the results of the candidates, taking up one group of subjects at a time. In this phase, the candidates 'marks scored are considered and the relevant clusters of students have been identified. Support Vector

machines are employed to form the clusters of candidates. The parameters for determining the levels of aptitudes are the subject (e.g. Data Structures), the sub-topic (e.g. searching and sorting algorithms), the concept ranking, the number of questions administered in that group, marks scored. At a single instance, an average of 150 to 200 candidate records are going to be analyzed. Initially plots of these candidate records, with two features per plot, (e.g. marks on X- A sample plot plotted in this way, drawn using Python's Matplotlib library is shown in Fig.1.

Fig.1 shows the scatter plot drawn to depict the distribution of marks vs the aptitude level for a set of 150 data points. The X-axis plots the marks whereas the Y-axis plots the aptitude level. The two plots depict the distribution for two sub-topics in data structures, namely "linear data structures" and "searching and sorting algorithms".

From this pairwise feature analysis, candidate clusters are picked up with an assigned level of aptitude. For convention, "Top scoring" group of candidates is referred to as cluster "A"—where the score is between 70% of the marks and 90%, "Average" scoring candidates is referred to as the cluster "B" where the score is between 45% of the marks and 70% of the marks and "Below Average" scoring candidates are referred to as cluster "C" where the score is less than 45% of the marks.

Further, the same data files are analyzed by employing the library functions available in the Scikit-learn package of Python. Specifically, the SVC—Support Vector Classification module is used with the data size to be of 150–250 records on an average. During the implementation, the data is divided into 80% training data and 20% test data. The target variable, or the variable to be predicted is set to the "aptitude level". The SVC kernel used in this implementation is the linear kernel and the value of gamma is varied suitable so as to see what changes the prediction from the SVC module will result. The best results of the exercises and iterations are considered for drawing the conclusions. For model evaluation, the classification report generated from the built in method "Classification Report" from the Python package "metrics" shows 100% of precision for the "Top_scoring" class and

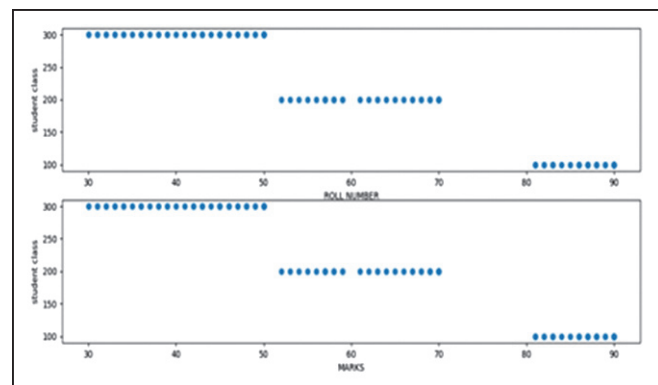


Figure 1: Scatter plot showing marks vs aptitude level

"98%" for the "Average" class and 97% "Below Average" experiments conducted.

This cycle of analysis is for one set of data, namely the results of the undergraduate examinations. A similar analysis is done on the results of the tests administered to the control group and these series of tests is consisting of both descriptive type of questions as well as multiple choice questions. In the first phase, the Bloom's taxonomy of verbs were used in order to assign concept ranking to the already available set of questions. In this phase, the questions are designed in such a way to meet a certain level of aptitude to be tested in the candidates. The aptitude level of the candidates established in the first phase is now taken as a benchmark and in this phase, multiple choice questions are given in more number, because ultimately the question set that is getting evaluated is the one in the actual entrance examination and that is totally based the multiple-choice questions. The results of this phase of analysis also is done by employing the same techniques in the previous phase and similar clusters of candidates with a certain level of aptitude, either A, B or C are going to be identified. Once this is done, the mapping between the two sets of clusters is going to be done. This mapping is going to validate the aptitude of the candidates further, by doing a stricter evaluation. Multiple

Table 1: Subject: data structures

	No.of students tested	Sub-topic	Cluster type	No. of students in the cluster
1	150	Linear data structures	A	50
2	150	Linear data structures	B	40
3	150	Linear data structures	C	60
4	150	Non linear data structures	A	60
5	150	Non linear data structures	B	40
6	150	Non linear data structures	C	50
7	150	Searching and sorting algorithms	A	60

Table 2: Identification of clusters of aptitude

	Student cluster size	Aptitude level	Mapped student cluster size	Topic	Alternate question set recommended (y/n)	No of questions changed
1	500	A	580	Linear data structures	Y	5
2	600	B	640	Searching and sorting algorithms	Y	3
3	600	C	620	Linear data structures	N	0
4	700	C	750	Number systems	N	0
5	700	A	750	Operating systems	Y	3

choice questions test a different dimension of the aptitude of the candidates. Again, the SVM model proves itself to be a good model by showing accuracy level of more than 98%.

At the end of these two phases, the aptitude of the candidates has been successfully established and the following typical kind of distribution of clusters can be seen, The Table 1 shows the results of these two analysis phases over an entire year of results for the subject data structures.

As it can be observed from Table 1 the analysis is able to show the distribution of the candidates across clusters, as it is, with an accuracy of more than 98%

In the third phase of an analysis, the marks of the entrance examination results are done in similar ways and again clusters of candidates are evolved. Here, the questions are multiple choice questions only and we are analyzing the set of questions and results where there is a potential change required. Now the updated clusters from the second phase are going to be mapped with the current clusters and here is where the decision support system will come into picture. The clusters are mapped subject wise and sub-topic wise. If there are mapping clusters between the sets are present with a similarity factor of around 75% , the questions are going to be retained. Otherwise, the decision support system will recommend what should be the new set of questions in that sub-topic or the subject as a whole. On the whole, the decision support system will consider the number of students that are present in a cluster and a predictive analysis is made to predict the number of prospective candidates who might be present in a mapped cluster for the next examinations. This prediction is based on the three phases of analysis that has been explained in this section.

8.0 Results and Discussions

The decision support system will basically recommend blue prints of question papers based on the aptitude levels of the candidates, looking at the clusters evolved by the analysis of data. One can change the questions to move on to a higher order of cognition level if a certain number of candidates are

consistently staying at the same level of aptitude , or move towards framing a question set of lower order of cognition level if there are too many candidates at a certain level of aptitude and that pattern repeats over time. As a thumb rule, the examiner can form clusters of 500 to 600 candidates for the real time scenario and go on to change the questions accordingly. (the number 200. Of candidates mentioned in the Analysis is for experimentation, clusters can be combined without any change in the accuracy involved, because the efficacy of the methodology used is good). The examiner can design, clusters of questions mapping with the clusters of candidates – typically such as cluster AA set of questions for cluster A set of candidates. From the actual analysis performed in the current work, the following kind of recommendations are possible to be given.

9.0 Conclusions

The current work basically makes an attempt to solve a current problem that exists in the context of examination system in higher education. The actual work-wise contribution is that it gives a tangible method to devise blue prints for a number of examinations and not just MCA examinations. The method used in this work can be used to analyze and predict the student performance across many kind of examinations at the undergraduate level. The important point to be noted is that this study is a post-examination study and hence does not involve a study of many other factors responsible for the results to emerge in a certain patternized way. Factors such as teacher's aptitude, pedagogical methods used, and in many situations, factors such as the socio-economic status of the students involved, financial status of the family can indeed influence the results of the candidates, but they are not part of this study.

The technique of analysis used, namely Support Vector Machines, works well when the data size is below 1000 and its accuracy drops down for higher data sizes. The analysis done in this work is basically using two-class classification and this can be extended to multi class classification by

employing the advanced kernels available with Support Vector Machines. But for the current context the pair wise comparison of features works well and produces good results.

As an extension of the work, interested researchers can consider employing the methods used during the stages of teaching itself, that is, concert the study to a pre-examination study. By this, both the teacher and the taught can get to know their level of teaching – learning at all the stages in the duration that a course is taught. The same techniques can also be used as feedback mechanisms with a proper implementation and scheduling of the teaching-learning activities in any general setting.

This work is an extension of a doctoral work by the same researchers on Decision Support Systems.

10.0 Acknowledgments

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