Reducing the duration of Higher Education Study with Sequenced Course Recommendation using Categorical Subset Summation Algorithm

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ABSTRACT--- In recent years, gen-y student's learning pace is expanded on account of which the students could complete the required courses before the duration of their degree program. Students enroll the courses in their very own successions and interests during the adaptable course enrolment process. Course arrangement proposal encourages the students to finish their degree program before the duration of the study. This paper proposes a course suggestion framework using categorical subset summation algorithm to decrease the higher education study duration. This model is evaluated by comparing the proposed method with the current course registration patterns followed at our university.

1. INTRODUCTION

Students are permitted to pick courses in succession amid customized and adaptable course choice [1-3] based on certain constraints [1-2]. The duration of study is extended when the courses are selected without appropriate sequence and planning [1][4] but the grades of the students and their domain knowledge are improved when the courses are wisely recommended in sequence by considering their interests [1-2]. Before the end of the graduation time, students regularly focus on their career-related growth for succeeding with a great dream job opportunity or higher studies along with their regular completion of courses with great grades. Before they leave the university, if the students'complete the required credits within the duration of the degree, they will be set free with no course credits and hence get more time to concentrate on their profession related activities. This paper proposed one such strategy such that the students are suggested with courses with more courses by maximizing credit limit for each semester so that the number of semesters of the degree program is reduced.

A subset sum problem is discovering every conceivable subset from the given arrangement of positive numbers with the end goal that the sum in every subset is equivalent to some steady esteem. Subset sum with knapsack qualities [5] is the modification of subset sum problem in which each subset may not be exactly equivalent to steady esteem but can have value could be equal or lesser than equal to a sum. The subset which has knapsack qualities are indicated as optimal subsets. Existing exploration for subset aggregate considers the data items which are independent but not dependent on each other. The proposed categorical subset summation algorithm considers data items of dependent nature which are sub-grouped into initial subsets and then formed with final subsets with optimal sums.

The undergraduate computer science and engineering curriculum courses considered in this paper are specified with a course hierarchy level identified based on the course prerequisite(s). The courses are initially divided into subgroups based on their prerequisite dependency and then formed with final optimal disjoint subsets using categorical subset summation algorithm such that the sum of credits of each subset should be less than or equal to the credit limit (LC). The course combinations selected for each subset with said LC is then distributed to each semester. Courses distributed for a semester will not be distributed for the other semesters and thus they are disjoint subsets. Brute Force method is used in the proposed method for generating the course combinations with optimal sum. Courses with prerequisite constraint are dependent to such an extent that a course can be recommended for a student in a semester only when the prerequisite(s) of a course was already completed by the students in their previous semesters. Sequentially the courses are distributed to each semester one by one.

2. CATEGORICAL SUBSET SUMMATION ALGORITHM

A categorical subset summation algorithm is proposed in this paper in which the courses are clustered into the initial subsets based on the courses' prerequisite dependency. Further subsets are formed such that the sum of course credits of each subset is equal to a sum 'x'. The notations and parameters considered for each course are as follows.

- There are 'n' mandatory curriculum courses to be completed before 'k' semesters.
- 'm' is the standard number of semesters per degree programme and the value of 'k' specifies the number of semesters a student takes to complete the degree.
- 'LC' is the credit limit set for each semester. The sum of credits recommended to each semester should be limited to LC.
- 'l' is the maximum hierarchy level of all the courses.
- Set of courses $\{Cr_1, Cr_2, \ldots Cr_n\}$ identified with their course credits $\{ CrC_1, CrC_2 \ldots CrC_n\}$, course hierarchy

Revised Manuscript Received on February 11, 2019.

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$\{CH_1, CH_2, \ldots CH_n\}$, course prerequisite weight $\{WP_1, WP_2, WP_n\}$ where the hierarchy is calculated based on the course prerequisites and the prerequisite weight is calculated based on the number of courses for which a course is a prerequisite course.

- Courses clustered as initial subsets are specified as CL and the courses that falls on each level is specified with a set of courses $\{CL_i\}$ and the corresponding course credits, hierarchy and prerequisite weight.

The objective of the proposed method is to minimize the duration of the program by maximizing the credits restricted to the credit limit (LC) for each semesters' course credits summation.

arg min k

k = 1….m

arg max CCS_j

k = 1….m

where CCS_k is the sum of credits of semester k

Subject to

Rule 1:

$$CCs_k = \sum_{CrC_i \in CS_k} CrC_i <= LC$$

Rule 2:

$$\sum CCS_k = CT$$

Where CT is the total credits of all courses

Algorithm: Reducing the duration of the degree programme using Categorical Subset Summation Algorithm

1. //Hmax is considered as the maximum level of the hierarchy from the set of courses
2. //LC_h is the set of courses clustered in each hierarchy level
3. //Set a threshold value for the minimum number of credits to be considered for a semester.
4. Set Semester Number NS=1, Semester k=1, and hierarchy h=1
5. Calculate Credit limit LC = CT/Hmax
6. For each course in LC_h
7. Select course combinations such that the sum of credits<=LC and with maximum CCS_k

$$CCS_k = \sum_{CrCi \in LCh} CrC_i$$

   a. If more than one combination has the maximum CCS_k, select course combinations with maximum prerequisite weight.

$$PWS_k = \sum_{WPi \in LCh} WP_i$$

   b. If more than one combination has the maximum PWS_k, select course combinations in random
8. Distribute the Selected Course Combination to Sem_k
9. Append the courses which are not distributed to Sem_k to LC_{h+1}
10. Increment the value of k, h, and NS by 1
11. Exit loop when h>Hmax
12. If the NS^{th} semesters' sum of credits is less than the threshold, Increment LC by 1 and repeat the algorithm from 3 to 11
13. If the threshold credit is less in the NS^{th} semester
    a. Increment the value of LC by 1 and later repeat step 3 to 10.
    b. When the number of iterations is reduced in the $NS+1^{st}$ semester, current course distributions are considered
    c. Else the previous iterations' course distributions are considered.

3. RESULTS AND DISCUSSIONS

Our university undergraduate computer science and engineering curriculum courses and the students' registration patterns are considered for implementing the proposed methodology. In our university, based on the registration patterns analyzed during their pre-last semester, 78% of students register for only half of the credit limit. They are in a situation to focus on their profession oriented preparations alongside their enlisted courses. Students could complete the required course credits before the pre-last semester when the students are recommended with the courses in sequence using our proposed strategy. The proposed strategy is assessed on the choice based course registration patters followed at our university. Test dataset adjusted from the educational modules have 14 courses are identified with the course credits, course prerequisites, course hierarchy levels and course prerequisite weights as indicated in Table 1. In the event that a course is not related to prerequisite dependency, it is determined as "None" or with the set of course prerequisites otherwise.

Based on the hierarchies specified for each course, they are subgrouped into initial clusters. Course distribution using categorical subset summation algorithm (CSA) initially choose the courses from the first level and distributed to semester one. The courses that are not distributed to semester one will be added to the course list in the second level and the process continues until all the courses are distributed to the required semesters. Whenever the courses from a level are added to the next level, there might be a possibility of the occurrence of prerequisite and post requisite in the same level. So the CSA checks for the dependency of the courses during every distribution.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Table 1: Courses with prerequisite constraints

Course Code	Course Credit	Course prerequisite	Course Hierarchy	Course Prerequisite Weight
C1	4	None	1	3
C2	4	None	1	5
C3	4	C1	2	2
C4	4	C1, C2	2	4
C5	3	C3	3	0
C6	4	C1, C3	3	1
C7	5	C8, C2	2	0
C8	3	None	1	1
C9	4	C4	3	0
C10	4	C2	2	0
C11	3	C4	3	0
C12	4	C4	3	0
C13	3	None	1	0
C14	3	C6	4	0

Table 2: Course Distribution using Categorical Subset Sum Algorithm by maximizing the credits of a semester

Semester Number	List of courses with LC = 13	List of courses with LC = 14
1	C1, C2, C8	C1, C2, C8, C13
2	C3, C4, C7	C3, C4, C7
3	C6, C9, C12	C5, C6, C9, C11
4	C5, C11, C10, C13	C12, C10, C14
5	C14	-

A sample set of courses specified in table 1 is applied with the CSA algorithm. Initially, LC is considered as 13 credits as per the calculation made in the CSA algorithm. The course distribution is analyzed and found that the courses are distributed to five semesters as depicted in table 2 and the corresponding credits per semester as depicted in table 3. Since the fifth semester has course credits less than the threshold limit, the next iteration is executed with the credit limit LC as 14 and found that there were no courses distributed to semester 5 and thus by reducing the number of semesters. The iteration will not be repeated more than one time since it obviously increases the sum of credits of a semester and also the credit limit constraint could not be satisfied for a semester.

Table 3: Total Credits per semester as per recommendation in table 2

Semester	Credit Sum with LC = 13	Credit Sum with LC = 14
1	11	14
2	13	13
3	12	14
4	13	11
5	3	-
CT	52	52

The method proposed by Xu et.al distributes 5 courses per semester such that the recommendation could increase the GPA of the student and also the time taken for a students' graduation is also minimized [1]. Domain-based course recommendation is proposed by Parameswaran et. al in which the courses are recommended with constraints such that a quantum number of courses in each domain has to be taken by the students in each semester [2]. In this paper, the proposed method considers the sum of credits to be considered for a semester for course recommendation instead of considering the number of courses to be recommended for a semester. Based on the analysis of the CSA algorithm, when the credit limit LC is increased from 13 to 14, the number of semesters got reduced as specified in table 3. And this maximizing credit per semester within the credit limit has reduced the duration of the degree.

The complexity of the algorithm is progressively diminished since the courses are isolated into introductory subsets dependent on their chains of importance. Indeed, even with most dire outcome imaginable, if n-1 courses fall on the chain of command level 1 and one course falls on progressive system 2, the multifaceted nature of the calculation will be $O(2^{n-1})$. CSA algorithm works for any curriculum of any university subject to prerequisite and credit constraints.

4. CONCLUSION

This paper proposes a sequential recommendation of courses with credits and prerequisite constraints using categorical subset summation algorithm which lessens the length of degree program of an understudy by expanding the number of credits of a semester inside as far as

possible. The trial results demonstrate the decrease of the span of concentrate with an alternate course suggestion technique.

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