Artificial Intelligent Rule-Based Optimization for Course Allocation Challenges

ISMAIL OLANIYI MURAINA;
Computer Science Department, School of Science, Adeniran Ogunsanya College of Education, Lagos, NIGERIA

SEGBENU JOSEPH ZOSU
Technical Education Department, School of Vocational Education, Adeniran Ogunsanya College of Education, Lagos, NIGERIA

Abstract -- Anytime we are crucial with time, accuracy, and error free of processing data, using machine learning tactic to handle the necessary procedures always prove encouraging and convenient than manual methods. The usual way of solving the general assignment problem by most institutions is to manually examine the full list of courses in some predefined order and for each course to find a corresponding shortlist of best-fitting lecturers, and then assign one of those lecturers to the course. This practice is simple and can be accomplished by a HOD of the department, the HOD, from his/her experience, may use search tools (Qualifications, Years of experience, area of specialization) to search for a lecturer with characteristics or criteria required by the course, to allocate courses to such lecturer. However, the procedure has the following significant drawbacks: It is tedious, repetitive, and time-consuming. Since the shortlist of matches is not prioritized within itself, it requires further manual work to rank-order the individuals in the shortlist and is thus likely to result in a suboptimal choice, even for the single course currently considered. The first course considered is likely be assigned the best-found competent lecturer for the course (a greedy policy), even though that lecturer may be better suited to other courses that have not yet been assigned. In searching for lecturers who possess a number of desired attributes, all attributes are viewed as having the same importance. When some attributes are of higher importance than others, finding the best matches must be achieved manually by first searching for lecturers with the most important attribute, then reducing the list to those also having the next important attribute, and so on. In carrying out this procedure, it is likely to lead to a serious confusion of allocation. Given the above drawbacks, the potential for large amounts of data, and the need for a short response time, an automated procedure to optimize the set of assignments could offer a significant benefit, hence the reason for solving the assignment problem would be achieved successfully. This paper looks into effectiveness involving in the allocating the teachers to the relevant courses,

Keywords: Artificial Intelligence, Course Allocation, Optimization, Visirule, Assignment Problem

1. Introduction

The assignment problem (AP) is a discrete and combinatorial problem where agents are assigned to perform tasks for efficiency maximization or cost (time) minimization. AP is a part of human resource project management (HRPM). The AP optimization model, with deterministic parameters describing agent–task performance, can be easily solved, but it is characteristic of standard, well-known projects realized in a quiet environment [1]. The assignment problem is a special case of the transportation problem where all sources and demand are equal to 1. The basic problem in operations research is to assign tasks to facilities on a one-to-one basis in an optimal way. The problem may be to find the best assignment of workers to jobs, football players to field positions, equipment to construction site and so forth. The main objective of assignment problem is to minimize the total time to complete a set of tasks, or to maximize skill ratings, or to minimize the cost of the assignments. Assignment problem has been used in a variety of application contexts such as personnel scheduling, manpower planning and resource allocation [2].

Reference [3] developed a procedure for assigning teachers to courses based on a simple linear

programming technique. According to [4], the assignment problem (AP) is broadly known as a deterministic and combinatorial problem in operations research, discrete optimization, and project management [5], [6].

Carried out and analyzed the assignment problem with uncertain parameters.

General Mathematical Model of Assignment Problem

$$Min\ Z = \sum_{i=1}^{n}\sum_{j=1}^{n} eij\ xij$$

$$Subject\ to:$$

$$\sum_{i=1}^{n} xij = 1, j = 1, \dots, n$$

$$\sum_{j=1}^{n} xij = 1, i = 1, \dots, n$$

ij x ∈ {0, 1}, i, j = 1, …, n

Where:

Xij = the assignment of lecturer i to course j

Cij = the regret cost or time of assigning lecturer i to course j

The first set of constraints implies that each lecturer is assigned to one and only one course and the second set of constraints implies that to each course is assigned one and only one lecturer. It should be noted that in addition to the minimization of assignment cost, an assignment problem may also consider other objective functions such as the minimization of completion time. When the assignment problem is considered with the minimization of assignment cost as the objective function, it is called the cost minimizing assignment problem. Assignment problem has been used in a variety of application contexts such as personnel scheduling, manpower planning and resource allocation [2].

According to [7] matching highly skilled people to available positions are high-stakes task that requires careful consideration by experienced resource managers. A wrong decision may result in significant loss of value due to understaffing, under-qualification or over-qualification of assigned personnel, and high turnover of poorly matched workers. While the importance of quality matching is clear, dealing with pools of hundreds of jobs and resources in a dynamic market generates a significant amount of pressure to make decisions rapidly. We present a novel solution designed to bridge the gap between the need for high-quality matches and the need for timeliness. By applying mathematical programming, we are able to deal successfully with the complex constraints encountered in the field and reach near-optimal assignments that take into account all resources and positions in the pool. The considerations include constraints on job role, skill level, geographical location, language, potential retraining, and many more. Constraints are applied at both the individual and team levels. This study models staff course allocation assignment problem as an assignment problem. The model developed could be adopted for any problem that can be modelled as an assignment.

Table 1a: Relative ratings of lecturers to various courses

	PL	***CNM MPL GD***	***DPD MIDS SAD***	***NS NM***	***GCA CO***	***TLCS EDD***
Lecturer I	***92***	***56***	***84***	***91***	***95***	***98***
Lecturer II	***30***	***91***	***41***	***73***	***94***	***23***
Lecturer III	***25***	***27***	***30***	***68***	***90***	***50***
Lecturer IV	***67***	***53***	***62***	***52***	***93***	***51***
Lecturer V	***82***	***42***	***53***	***55***	***84***	***46***
Lecturer VI	***20***	***88***	***31***	***30***	***53***	***37***

Mathematical Model of Table 1a

Min =

$8x_{11}+44x_{12}+16x_{13}+9x_{14}+5x_{15}+2x_{16}+70x_{21}+9x_{22}+59x_{23}+$
$27x_{24}+6x_{25}+77x_{26}+75x_{31}+73x_{32}+70x_{33}+32x_{34}+10x_{35}+$
$50x_{36}+33x_{41}+47x_{42}+38x_{43}+48x_{44}+7x_{45}+49x_{46}+18x_{51}+$
$58x_{52}+47x_{53}+45x_{54}+16x_{55}+54x_{56}+80x_{61}+12x_{62}+69x_{63}+$
$70x_{64}+47x_{65}+63x_{66}$;

Subject to:

$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} = 1$;
$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} = 1$;
$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} = 1$;

$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} = 1;$
$x_{51} + x_{52} + x_{53} + x_{54} + x_{55} + x_{56} = 1;$
$x_{61} + x_{62} + x_{63} + x_{64} + x_{65} + x_{66} = 1;$
$x_{11} + x_{21} + x_{31} + x_{41} + x_{51} + x_{61} = 1;$
$x_{12} + x_{22} + x_{32} + x_{42} + x_{52} + x_{62} = 1;$
$x_{13} + x_{23} + x_{33} + x_{43} + x_{53} + x_{63} = 1;$
$x_{14} + x_{24} + x_{34} + x_{44} + x_{54} + x_{64} = 1;$
$x_{15} + x_{25} + x_{35} + x_{45} + x_{55} + x_{65} = 1;$
$x_{16} + x_{26} + x_{36} + x_{46} + x_{56} + x_{66} = 1;$

2. Related Literatures

Some of the reviewed studies include [8] who conducted a research on important research tool in operations research as it was applied to a particular structure of the multi-criteria assignment problem. The study addressed the problem of effectiveness of feasible solutions of a multi-criteria assignment problem which was done in two steps: the first one determined whether or not a given feasible solution of a multi-criteria assignment problem was a real efficient one while the second step was based on what will happened if the feasible solution was not real efficient, by providing a real efficient solution that dominated that not real efficient solution.

Reference [9] from Indonesia carried out a research which addressed time-tabling problem in a university. The study focused the problem of assigning teachers to the courses and courses sections. In this study a mathematical programming model was formulated, simulated annealing (SA) and tabu search (TS) algorithms were proposed to solve the problem. One phase involved allocating the teachers to the courses and determining the number of courses to be assigned to each teacher. The other phase involved assigning the teachers to the course sections in order to balance the teachers' load. At the end, the computational results showed that in general, tabu search performed better than simulated annealing and other previous work. For the real data sets, the computational results showed that both proposed algorithms yielded better solutions when compared to manual allocation done by the university. [10] embarked on a study by introducing a new approach to assigning one method to solve a wide range of assignment problem in which he obtained a reduced matrix to arrive at optimal solution. A paper presented a review pertaining to assignment problem within the education domain the paper classified assignment problems into two, which were timetabling problem and allocation problem. The timetabling problem was further classified into examination, course, and school timetabling problems, while the allocation problem was divided into student-project allocation, new student allocation, and space allocation problems [11]. Also, [12] conducted a study in multiagent systems; they formulated the problem as a multiple travelling salesmen problem (MTSP), which was an extension to the well known travelling salesman problem (TSP), both considered to be NP-hard combinatorial optimization problems. They proposed a solution in which agents interacted in an economic market to win tasks situated in an environment. The agents strived to minimize required costs, defined as either the total distance travelled by all agents or the maximum distance travelled by any agent. Hence, [13] carried out a study they applied the assignment model to the course allocation problem in Nigeria tertiary institution in order to maximize lecturers' effectiveness. The study revealed that the adoption of the assignment model in course allocation is a an attempt to help the institutions to experience 13.20% increment in lecturers' effectiveness which could lead to increase in the quality of education students get. The study concluded that assignment model was a unique model that could be used to solve course allocation problems in tertiary institutions

In reference [14] study on personnel assignment problem and proposed solution to solve the problem was conducted, the analysis results revealed potential solution approaches, the trends in application of existing solution methods, and some potential future research areas. It was observed that artificial intelligence and machine learning still have a good potential to contribute to this field of research in different applications. Reference [1], suggested an algorithm combining binary programming with scenario planning and applying the optimism coefficient, which described the manager's nature (attitude towards risk). The procedure was designed for one-shot decisions (i.e., for situations where the selected alternative is performed only once) and pure strategies (the execution of a weighted combination of several decision variants is not possible) when considering new (innovation or innovative) projects or projects performed in very turbulent times

Reference [15], carried a study on Conference Paper Assignment Problem (CPAP) which resolved the problem of assigning reviewers to conference paper submissions in a manner intended to minimize whingeing. It was assumed that papers were reviewed by members of a preset program committee (PC), each of whom has the opportunity to bid on papers prior to the assignment algorithm being run. In the study, they showed that CPAP was in P if the only information given was individual program committee members' preferences for individual papers. However, if both preferences and expertise (based on, say, keywords) were given, the problem was potentially more complex. Reference [16] presented the problem of allocating a

set of indivisible objects to agents in a fair and efficient manner.

In all of these cases, the consequences of failing to find the best assignments for the courses are extremely severe. Problem of assigning teachers or lecturers to courses can be in different forms: When under-qualified lecturers assigned to highly logical or complex courses like programming languages, when over-qualified lecturers assigned to less logical or complex courses like introduction to Computer, and when a total number of courses assigned smaller than the maximum achievable of a lecturer. An under-qualified assignment may result in student's dissatisfaction with the course, eventual reduction or loss of students enrolling for the course, and loss of referrals from the students. If problem of assigning teachers or lecturers to courses is not quickly checked it may result in mass failure from the students, adding more loads to other staff in the department and eventual decreased in number of students to the university or college, and the general dissatisfaction of the students and society at large.

3. Materials and Methods

In our methodology, we shall use different applications in solving our problem. Though the algorithm used was in line with Hungarian approach of solving assignment problems. The study involved all Computer Science lecturers in the department (AOCOED). Only six anonymous lecturers were used to assign six courses which were already grouped.

Altogether, there are 20 courses offered by computer science students taken from Nigeria Certificate in Education Minimum Standard (NCEMS, 2020) for sciences apart from SIWES and teaching practices. For easy interpretation, all the 20 courses are grouped into six categories based on their similarities, prerequisites and relevancies. All programming languages are grouped as PL, Computer networking, Computer maintenance, Microprocessor, Computer graphics and Desktop publishing are grouped as CNMMPGD, Data processing, Database management system, Data structure and system analysis and design are grouped as DPDMSDSSAD, Number system, Computer logic, Numerical method are grouped as NSCLNM, General computing, Application packages, Operating systems, Computer operations are grouped as GCAPOSCO, while Teaching and learning computer science, and E-learning design and development (Blended approach) are grouped as TLCSEDD. Hence, all the courses are grouped under six headings.

In the same vein, lecturers were grouped into six categories for easy assignment to various courses with respect to their efficiency in each of the courses listed earlier. The criteria were based on their first degree area (Computer science, Computer science education, Computer education or Computer engineering), followed by masters' degree area of specialization as well. Next was based on area of which they were pursuing their PHD. Finally, we considered their interest area as well as years of experience to handle certain courses effectively.

All these criteria were incorporated into Visirule software artificial intelligence-base rule. Sequential questions are followed to the stage where the graphical boxes generate relevant courses for such lecturers based on questions option displayed when the software run to generate right-matching answers. The courses offered in Computer Science Department at Adeniran Ogunsanya College of Education were grouped into six categories as explained in details below:

The rating was calculated using the following criteria:
Each lecturer was scored over 100%, their rating score were presented in the table 1a&b. Since assignment problem is a type of transportation problem, we need to minimize instead of maximizing. So, we applied regret matrix by deduction every score from 100. The table 2 shows the result of regret matrix to be used for the problem

4. Results and Analysis

Table 1b: Relative ratings of lecturers to various courses

	PL	***CNM MPL GD***	***DPD MIDS SAD***	***NS NM***	***GCA CO***	***TLCS EDD***
Lecturer I	***92***	***56***	***84***	***91***	***95***	***98***
Lecturer II	***30***	***91***	***41***	***73***	***94***	***23***
Lecturer III	***25***	***27***	***30***	***68***	***90***	***50***
Lecturer IV	***67***	***53***	***62***	***52***	***93***	***51***
Lecturer V	***82***	***42***	***53***	***55***	***84***	***46***
Lecturer VI	***20***	***88***	***31***	***30***	***53***	***37***

Table 2: Regret matrix table

	PL	*CNM MPG D*	*DPD MSDS SAD*	*NSC LNM*	*GCAP DSCO*	*TLC SED D*
Lecturer I	*8*	*44*	*16*	*9*	*5*	*2*
Lecturer II	*70*	*9*	*59*	*27*	*6*	*77*
Lecturer III	*75*	*73*	*70*	*32*	*10*	*50*
Lecturer IV	*33*	*47*	*38*	*48*	*7*	*49*
Lecturer V	*18*	*58*	*47*	*45*	*16*	*54*
Lecturer VI	*80*	*12*	*69*	*70*	*47*	*63*

Table 3: Results of Microsoft Excel Solver, Lingo Solver and TORA solver

	Lecturers	*Course Assigned*	*Courses Allocated*
1	***Lecturer I***	TLCSEDD	Teaching and learning computer science, and E-learning design and development (Blended approach)
2	***Lecturer II***	NSCLNM	Number system, Computer logic, Numerical method
3	***Lecturer III***	GCAPDSCO	General computing, Application packages, Operating systems, Computer operations
4	***Lecturer IV***	DPDMSDSSAD	Data processing, Database management system, Data structure and system analysis and design
5	***Lecturer V***	PL	Programming Languages like BASIC, C, C++, Java, Python, HTML, CSS
6	***Lecturer VI***	CNMMPLGD	Computer networking, Computer maintenance, Microprocessor, Computer graphics and Desktop publishing

Table 4: The comparison of three solvers

Criteria Used	*Manual Solving*	*Microsoft Excel Solver*	*Lingo Solver*	*TORA(Temporary Ordered Routine Algorithm)*
Iteration Number	**6** Iterations	100 Iterations	14 Iterations	5 Iterations
Time Spent	4 Hours	45 Minutes	15 Minutes	4 Minutes
Skills Used	Mathematical Knowledge	Computational Skills	Programming Skills	Computing Skills

Application of Visirule to Help Solving Problem of Courses Allocation Problems

In similar way, Visirule intelligent software can be used to allocate courses without necessarily writing codes. So, Visirule software is always used as a decision supporting tool, in which the rules are basically and precisely presented using Logic Programming Model. The RSA-Expert can be of great use to researchers in making a firm decision in utilizing suitable statistical data analysis in researches [17]. It helps to overcome many of the problems associated with text-based rules and decision tables [18]. Visirule allows experts / researchers to concentrate on explaining and establishing the structure of the logic correctly using their chosen tools - those embedded materials that can assist researcher to accomplish his mission [19],[18]. The Visirule software, being free software, was used as a decision enabling tool, presented graphically based on a logic programming model [20]. According to [18] VisiRule provides a drawing environment, which helps to draw decision charts, and it can be immediately executed and verified, or exported as graphical objects or as program text for embedding within larger computer processes and/or applications

The Visirule software was used as a decision supporting tool, using Logic Programming Model to present RDS-Expert in a concisely and precisely way. The RDS Expert serves as a guide for researchers to use in making good decision regarding the type of research design fit their studies [21]. The VisiRule software made available by Logic Programming Associates is used in development of expert system. This software is decision charting tool, in which the

rules are simply defined by a combination of graphical shapes and pieces of text [19].

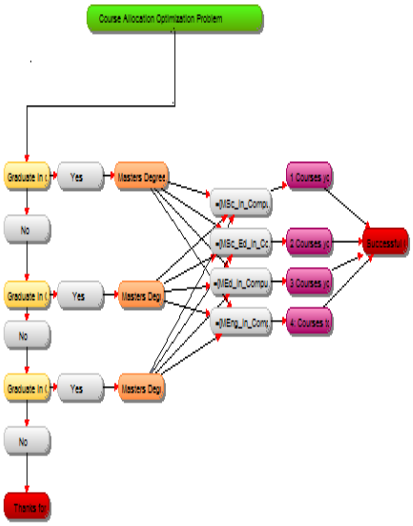

Fig. 1: Visirule Expert System Model to allocate courses to various lecturers

5. Discussion

The findings account that problem of assigning courses to lecturers could be solve using artificial intelligent rule-based models far better than the using of manual/conventional approaches. As it was illustrated in the table 4, it could be deduced that the use of solvers such as Microsoft Excel Solver, Lingo Solver, and TORA Solver performed so greatly compared to manual allocation of courses in terms of number of iterations to generate the final result, the time taken to complete the execution of the result and the skills required to implement those solvers. Though, manual iteration might be lower compared to some of the solvers but using manual assignment of allocating courses may prone to series of errors and at the same time takes a lot of time to complete the allocation. The HODs and whoever in charge of course allocation of courses may need to have fundamental basic knowledge of computing as a prerequisite to the use of the aforementioned solvers. At the same time, Visirule expert system complemented the use of three solvers by helping the HODs to conveniently allocate courses to the lecturers using decision procedures already embedded into the software. As shown in the fig.1, the green cox is the starting point, yellow boxes is a single question box that asks a teacher/lecturer area he/she did his/her first degree. In this, if the answer is no, it will proceed to ask another question and if the answer is yes it will move further to ask question relating to the second degree of such lecturer. The white boxes are to display the yes or no answers and link to other boxes. Orange boxes are multiple question option boxes while the purple boxes show the list of courses assigned to a lecturer after matching lecturers' qualifications, area of specialization and experience together and finally allocate all the courses to the lecturer. Expert systems/ knowledge based systems, a sub-branch of artificial intelligence, are consultative programs, which although limited in flexibility, have achieved levels of performance as comparable to that of human experts [19]. The use of visirule does not require one to write series of codes, it is by just picking the boxes and implement the processes [22]. It will generate codes which can be exported to different programming languages as well as html language

6. Conclusion

This study established the use of different solvers to ease the problems that HODs of any department might be facing in relation to allocating courses to most qualified and competent hands (lecturers/Teachers). Previous studies have used different mathematical manual approaches but proved very slow, error prone and time consuming in all ways. In the same vein, a novel approach of using expert system also applied in this study which has made this study a unique type compared to previous approaches. In this, no code is required in the use of visirule software to achieve a successful course allocation assignment problem.

References

[1] Helena Gaspars-Wieloch (2019)The Assignment Problem in Human Resource Project Management under Uncertainty Department of Operations Research and Mathematical Economics, Pozna´n University of Economics and Business, 61-875 Pozna´ n, Poland; Helena.gaspars@ue.poznan.pl

[2] Sonia, P M C (2008). Two-Stage Time Minimizing Assignment Problem. Omega articles on manufacturing magazines. 36 (5): 730-740.

[3] Andrew, G. M. and Collins, R., Matching faculty to course, College University, Vol.46, No.2, pp.83-89, 1971

[4] Ravindran, A. 2008. Operations Research and Management Science Handbook. Boca Raton, London and New York: CRS Press.

[5] Ding, Sibo. 2020. Uncertain random quadratic bottleneck assignment problem. Journal of Ambitient Intelligence and Humanized Computing 11: 3259–64. [CrossRef]

[6] Ding, Sibo, and Xiao-Jun Zeng. 2018. Uncertain random assignment problem. Applied Mathematical Modelling 56: 96–104. [CrossRef]

[7] Korsorku Simon (2012) Staff Assignment Problem. Thesis Submitted to The Department of Mathematics Kwame Nkrumah University of Science and Technology
[8] Odior, A O; Charles-Owaba, O E; Oyawale, F A (2010). Determining Feasible Solutions of A Multicriteria Assignment Problem. J. Appl. Sci. Environ. Manage. March, 2010 Vol. 14(1) 35 – 38
[9] Gunawan, Aldy and NG, Kien Ming. Solving the teacher assignment problem by two Metaheuristics. (2011). International Journal of Information and Management Sciences. 22, (1), 73-86. Research Collection School Of Information Systems. Available at: https://ink.library.smu.edu.sg/sis_research/4003
[10] Basizadeh, Hadi (2012). Ones assignment method for solving assignment problems. https://www.researchgate.net/publication/265498020 2345-2355
[11] Syakinah Faudzi, Syariza Abdul-Rahman, and Rosshairy Abd Rahman (2018). An Assignment Problem and Its Application in Education Domain: A Review and Potential Path. Advances in Operations Research
[12] Elad Kivelevitcha, , Kelly Cohen & , Manish Kumar (2011). Market-Based Solution to the Allocation of Tasks to Agents. Procedia Computer Science 6, 28–33
[13] O. Solaja, J. Abiodun, J. Ekpudu, M. Abioro, O. Akinbola (2020). Assignment problem and its application in Nigerian institutions: Hungarian method approach. International Journal of Applied Operational Research Vol. 10, No. 1, pp. 1-9,
[14] Arash Niknafs, Jörg Denzinger, and Günther Ruhe (2013). A Systematic Literature Review of the Personnel Assignment Problem. Proceedings of the International MultiConference of Engineers and Computer Scientists 2013 Vol II, IMECS 2013, March 13 - 15, 2013, Hong Kong
[15] Judy Goldsmith and Robert H. Sloan (2021).The AI Conference Paper Assignment Problem
[16] Akshay-Kumar Katta and Jay Sethuraman (2005). A solution to the random assignment problem on the full preference domain. Master degree Thesis, Department of Industrial Engineering and Operations Research, Columbia University, New York, NY.
[17] Muraina, I O, Rahman, M A, Adeleke, I A & Aiyegbusi, E A, (2013). Use of a Rule Tool in Data Analysis Decision Making. Journal of Information and Knowledge Management,Vol.3, No.3, www.iiste.org
[18] Bilgi N B, Kulkami, & Spenser C (2010). "An Expert System using A Decision Logic Charting Approach for Indian Legal Domain With specific reference to Transfer of Property Act".DOAJ
[19] Spenser C (2007). Drawing on your knowledge with VisiRule. IEEE Xplore. IEEE Potentials 26(1):20 – 25, Doi: 10.1109/MP.2007.343036
[20] Muraina, I O, Rahman, M A and Adeleke, I A (2016). Statistical Approaches and Decision Making Towards Bivariate and Multivariate Analyses with Visirule. British Journal of Education, Society & Behavioural Science, 14(2): 1-10
[21] Muraina, I O and Adeleke I A (2021). Researchers' Artificial Intelligence Expert System Rule-Based Decision Making Using Visirule. International Journal of Progressive Sciences and Technologies (IJPSAT), 28(1), pp.351-358
[22] Muraina I. O, Zosu S.J & Agoi M.A (2021). Expert System Rule-Based Optimization in Assigning Courses of Study. Latin America International Conference on Natural and Applied Sciences. Villahermosa, Mexico. November 5-6,