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Multi-Criteria Resource Allocation Approach to Artificial Intelligence Projects

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Abstract: The allocation of resources to competing project activities poses a critical challenge in project management. In this paper, a multi-criteria goal programming model was developed to determine the combination of time, labor and material resources along with the total amounts of resources required to execute an artificial intelligence project; with special focus on high quality data acquisition, running experiments and implementation into the real world. Using goal programming, the objective function is minimized so that minimum resource requirements are utilized during the stages of project execution. The sum of weighted deviations is minimized from the goal values and the projected completion time of the artificial intelligence project. Resource leveling is achieved by using the simplex method for linear programming; that requires solution of a minimization problem. A numerical example is presented for illustration that determines the allocation of time, labor and material resources to acquire high quality data, run experiments and fully implement the project. The solution provides feasible results; taking into account the contradictory nature of the criteria involved in executing project activities. The multi-criteria goal-based approach to resource allocation is effective as a resource leveling tool for time, labor and material resources for artificial intelligence projects; where completion time and the relevant resource costs can be prioritized if necessary

Keywords—: Artificial intelligence; allocation; goal; project; resources

1. INTRODUCTION

In a project management framework, optimal allocation of time, labor and material resources is crucial for successful completion of project activities at least cost. Management of an artificial intelligence project requires optimal allocation of resources during high quality date acquisition, experimental runs and implementation into the real world.

Getting high quality data is important and relevant sources of data may include: the internet, users and sensors. Since results can be limited by the quality of data and that data from the real world tends to be messy or incomplete, cleaning of garbage data is vital so that high quality data is obtained during the stage of high-quality data acquisition.

During the stage of running experiments, a degree of uncertainty usually prevails; predicting what can work and what cannot. It is therefore critical to ascertain the type of artificial intelligence that can work for the data selected. Careful selection of the best data needs must be done after thorough evaluation in order to support cost-effectiveness.

Implementation into the real-world demands creating value and putting what works into a practical perspective. Infrastructure must be built that can handle unexpected errors and malicious attacks; using a team of experts. Because new experiments can be run on old data as well as regular collection of new data, data storage is crucial; and data bases can provide a reliable way to store data for future use.

2. LITERATURE REVIEW

Resource allocation in artificial intelligence benefits from Kieling, Rodrigues et al [1]. The authors developed a model for human resource allocation in projects based on machine learning. The model learns about the allocation strategies used by the organization over time and makes recommendation based on this information. Related works on dynamic pricing with neural network demand models by Shakya, Kem et al [2] show how revolutionary algorithms can be used to optimize the pricing policy. This makes it flexible to model a range of different products and services; making it versatile enough to solve very complex models. The model is more consistent and adapts well in a range of different scenarios. In another development, Ferreira, Parreto, et al [3] examined optimization of radio resource allocation with multiple mutually exclusive goals, latency, throughput, fairness and spectrum efficiency. In this study, solution of the scheduling problem is presented by using temporal and geographical correlations of users and their traffic. A generalized framework is then put forward by Vengerov [4] who performis adaptive reconfiguration on a distributed system based on maximizing the long-term business value; defined as the discounted sum of all future rewards and penalties of the system. In related literature, Elmousalami [5] reviews different computational intelligence techniques and ensemble methods to develop practical prediction models. The most common artificial intelligence techniques are reviewed; as a basis to provide

the comprehensive knowledge needed to develop a reliable parametric cost model at the conceptual stage of the project. In related literature on artificial intelligence and allocation of resources, Haijun[6] examined artificial intelligence-based resource allocation in ultra-dense networks. This enables intelligent communication devices to learn and complete resource allocation. In [7], the author developed an expert system for resource allocation by incorporating variants of AI techniques in order to make the first use of the merit system for question selection. In a similar development, Krishnan et al [8] examined artificial intelligence in resource-constrained and shared environments; by predicting forthcoming era of AI systems; where reducing resource consumption, reasoning about transient resource availability, trading off consumption for accuracy and managing contention on specialized hardware could become the community's main research focus. Ware [9] however wonders whether artificial intelligence can alleviate resource scarcity as it could use a variety of inputs including weather conditions and predictions, market prices and geographical location to provide insights to farmers. In an effort to assist project managers, Munir [10] explained how artificial intelligence can help project managers to manage work by administering different projects with several resources.

3. MODEL DEVELOPMENT

An artificial intelligence (AI) project is considered whose goal is to minimize resource costs (labor, material) and time for successful completion of activities during high quality data acquisition, running experiments and implementing the project into real world.

3.1 Notation

(j=1,2,3) : Project stages for completion
(k=1,2,3): Goals to be achieved
Z : Value of objective function
P_k : Pre-emptive priority of k^{th} goal
d^+_k : Overachievement of k^{th} goal
X_j : Allocated time for completing stage j
T : Total time of completion
C_j Monthly total costs (including miscellaneous costs)
B : Budget of entire project
A_j : Monthly labor and material costs
LM : Total labor and material costs

3.2 Objective Function

Consideration is given to preemptive priorities, over/under achievement of goals, yielding the following function:

$$\text{Minimize } Z = \Sigma^3_{k=1} P_k(d^+_k + d^-_k) \quad (1)$$

3,3 Goal Constraints

The AI project is constrained in terms of time for completion, total cost(budget), labor and material costs.

Total time of completion

$$\Sigma^3_{j=1} X_j - d^+_1 + d^-_1 \quad (2)$$

Total Cost (Budget)

$$\Sigma^3_{j=1} C_j X_j - d^+_2 + d^-_2 = B \quad (3)$$

Labor and material costs

$$\Sigma^3_{j=1} A_j X_j - d^+_3 + d^-_3 = LM \quad (4)$$

4. GOAL PROGRAMMING MODEL

Minimize $Z = \Sigma^3_{k=1} P_k(d^+_k + d^-_k)$

Subject to:

$$\Sigma^3_{j=1} X_j - d^+_1 + d^-_1$$

$$\Sigma^3_{j=1} C_j X_j - d^+_2 + d^-_2 = B$$

$$\Sigma^3_{j=1} A_j X_j - d^+_3 + d^-_3 = LM$$

$$X_j , A_j , C_j , d^+_1 , d^-_1 , d^+_2 + d^-_2 , d^+_3 , d^-_3 \geq 0$$

4.1 Solution Procedure

The optimal solution in §4 is obtained following steps (i) to (iv) as follows:

(i) Start with the initial solution for which all decision variables are assumed to be at zero level
(ii) The objective function coefficients are preemptive functions; so P_1 , P_2 and P_3 are placed in appropriate places of the initial tableau
(iii) All d^+_k s must be considered at zero level, and hence only negative deviational variables d^-_k s must appear in the basis of the initial Tableau
(iv) Use the simplex method to solve the minimization problem until optimality is achieved.

5. IMPLEMENTATION

5.1 Data Description

In order to test the model in §4, hypothetical resource allocation problem for artificial intelligence (AI) project is introduced in this section. The estimated monthly costs (in USD) of carrying out the project are presented in Table 1 and Table 2.

Table 1:

Monthly Breakdown of Costs (in USD) of Artificial Intelligence (AI) Project

AI project stage (j)	Monthly Labor and Material costs (LM_j)	Monthly Total Costs (including miscellaneous expenses) (TC_j)
High Quality Data Acquisition (1)	590	989
Running Experiments (2)	1867	31306
Implementation into real world (3)	393	659

Table 2:
Budgeted Amounts (in USD) and Duration (in months) of Artificial Intelligence (AI) Project

Labor and Material Costs	Total Budget (Including miscellaneous expenses)	Duration (months)
22208	38738	6

In addition, the following priorities are desirable for successful completion of the Artificial Intelligence project.:
P_1 : Complete project in 6 months
P_2: Keep project expenditure within budgeted amount (77,476 USD)

5.2 Problem Formulation

The problem seeks optimal allocation of time to the stages of project (high quality data acquisition, running experiments and implementation into real world) in order to achieve the goals for time and total expenditure budget.

5.2.1 Goal Programming (GP) Model

Minimize $Z = P_1 d^+_1 + P_1 d^-_1 + P_2 d^+_2 + P_2 d^-_2$

Subject to:

$X_1 + X_2 + X_3 - d^+_1 + d^-_1 = 6$

$989X_1 + 31306X_2 + 659X_3 - d^+_2 + d^-_2 = 38738$

$590X_1 + 1867X_2 + 393X_3 - d^+_3 + d^-_3 = 22208$

$X_1, X_2, X_3, d^+_1, d^-_1, d^+_2, d^-_2, d^+_3, d^-_3 \geq 0$

5.2.2 Solution to GP Model

Using LINDO software, the following results are obtained:
X_1 = Time allocated for high quality data acquisition
= 0 months
X_2 = Time allocated for running experiments
= 1.09 months
X_2 = Time allocated for implementation into real world
= 4.91 months

5.2.3 Interpretation of Results

P_1 : Goal for completing AI project on time is fully achieved since $X_1 + X_2 + X_3 = 6$ months

However, this solution is illogical or impractical because without allocated time to high quality data acquisition stage, the project can fail since $X_1 = 0$

P_2 : Goal for keeping total project expenditure within budgeted amount is partially achieved since $989X_1 + 31306X_2 + 659X_3$
$= 989 (0) + 31306(1.09) + 659(4.91)$
$= 37,360$ USD
This is slightly below the total budgeted expenditure of 38,738 USD.

6.CONCLUSION

Optimal allocation of resources for Artificial Intelligence projects requires sharing the available resources judiciously so that project deadlines and budgets are met by project managers. That is why resource allocation is a critical aspect of any project; especially for efficient financial operations. Multi-criteria goal programming can be an effective tool to achieve these goals under preemptive priorities set for project completion.

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