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Time Allocation in Academia

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ABSTRACT

University professors all over the world are facing an increasing challenges to publish more and more high quality papers, get funds, and improve their citation indices. In many scientific disciplines, like engineering and computer science, research topics keep changing and professors' research agendas need to change as well. In this paper, we develop a mixed integer linear program (MILP) to model a university professor problem of selecting research topics. The problem aims to increase the professor's number of citations subject to time constraint and publication probability constraint. We also solve the suggested MILP using a max-min ant system. A case study for a professor in an industrial engineering department is also presented.

Keywords— *Ant Colony Optimization, Research Topic, Academia, Budgeting, Knapsack*

1. INTRODUCTION

University professors are under tremendous pressures to publish research papers, improve their citation indices, and possibly obtain external funds as discussed in Nakhaie [1] and Parker [2]. Professors, like workers in any other profession, have a learning curve [3]. Thus, their ability to publish in certain area increase with time. However, in schools like engineering and computer science, journal interests keep changing, and professors need to keep adjusting their research agendas [4]. Since time is a limiting resource, professors need to carefully select their research agendas to achieve multiple objectives, increase the number of publications, publish in high quality journals, and publish in new topics, in which practinoners and academians are interested.

In this paper, we develop a mathematical model for the optimization problem that a typical university professor, who is employed by a good university, implicitly solves. We then develop a max-min ant system (MMAS) to solve the developed model [5]. The developed model is then applied to a university professor in an industrial engineering department.

2. MATHEMATICAL MODEL

In this section, we develop a mix-integer linear program (MILP) to model a professor's optimization problem. The objective function of any professor is to maximize the objective function represented in Equation 1. In this equation, w_i and x_i represet the number of possible citations and the number of publication in topic $i \in N$, where N is the set of research topics. p_i is probability of accepting a paper in topic topic $i \in N$.

For each possible publication topic, there is a time invested in writing the paper, which definitely would include experimentation, surveying, or coding. Thus, for each topic $i \in N$ the researcher needs to invest t_i days in researching the topic. Time is a major concern for any professor, and the time invested in researching topics in set N should not exceed T. Eequation 2 represent the time constraint. Moreover, university adminstrations might impose a minimum number of publications to renew contracts; thus, the sum of prbobalities to publish papers should be greater than T, as shown in Equation 3. The decision variable of the professor model is x_i which shows the number of research papers submitted for publication in topic $i \in N$.

$$\max Z = \sum_{i=1}^{N} w_i p_i x_i \tag{1}$$

$$\sum_{i=1}^{N} t_i x_i \leq T \tag{2}$$

$$\sum_{i=1}^{N} p_i x_i \geq P \tag{3}$$

$$x_i \epsilon Z \tag{4}$$

2.1 A max-min ant system

To solve the professor problem that was modeled using Equation 1-4, we use a meta-heuristic algorithm to solve this problem [6]. The algorithm used is a MMAS that have been successfully applied to several problems, for example, travelling salesman problem [7], scheduling [8], and covering problems [9].

Ants in nature have collective intelligence. To find the shortest route from point A to point B, ants lay a chemical called heromone to know their path their nest. Pheromones have an evaporation rate; thus, if the path is long, time for pheromone evaporation increase and not much chemicals are laid along this path. When an ant from a later bach wants to select its path, it selects paths with more pheromones with higher probabilities. So, pheromone trails along short paths tend to increase and a long short paths tend to decrease. After a while, ants abandon the long path and only follow the short paths. This foreaging ant behavior is imitated in our MMAS algorithm.

A typical implementation of a MMAS starts with developing a construction graph as shown in Figure 1. Ant are divided into G generations. An ant in the first generation, go through the construction graph and at each step, the ant selects a research topic. This topic reduces the available time to spend on researching other topics. Thus, an ant keeps adding topics as long as time is available. Once all ants from the first generation find a time feasible solution, the best solution, the one that maximizes the objective function shown in Equation 1, increases the pheromone trails along the path it took while pherome trails along other paths are reduced as shown in Equation 2. The τ_{is} is the pheromone trail algong the path to node representing topic $i \in N$, whereas $0 < \rho < 1$ represent the evaporation rate. The indicator function $1.\{condition\}$ has a value of 1 if the condition is satisfied. Thus, the first term of Equation 1 shows that $\Delta\tau$ pheromones are added to arcs belonging to the best solution.

$$\tau_{is} = \Delta\tau 1.\{if\ topic\ i\ is\ selected\ in\ step\ s\ by\ the\ best\ ant\} + \rho\tau_{is} \quad 5$$

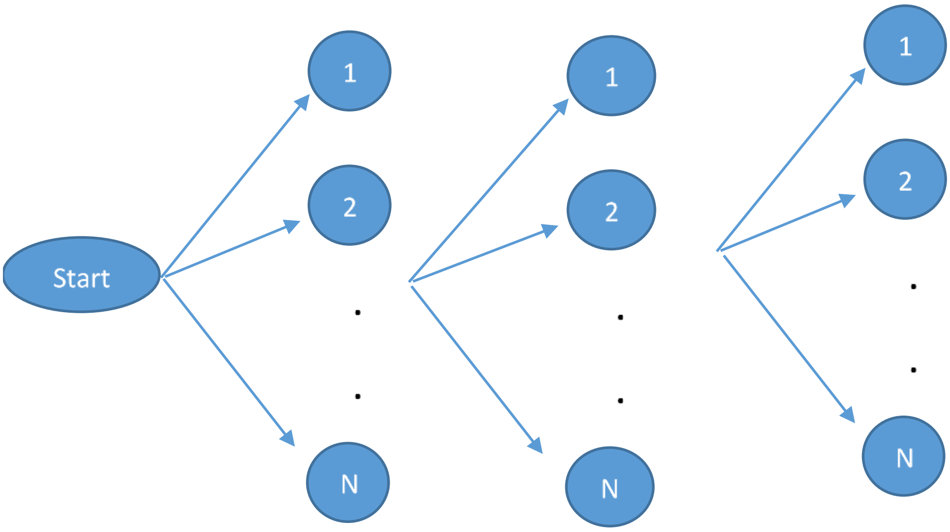

Figure 1. A construction graph for the professor optimization problem

An ant belonging to a later generation probabilitically selects an arc as shown in Equation 6. The selction probability of topic $i \in N$ is step s, P_{is}, depends on both the pheromone trails along this path τ_{is} and heuristic information about this path, π_{is}. In Equation 6, α and β show the importance of the pheromone trail and heuristic information, respectively. To avoid convergence to a single solution and force ants to keep exploring new solutions, a MMAS enfoces a lower and upper limits for τ_{is}, which we denote by ρ_{min} and ρ_{max}, respectively.

$$P_{is} = \frac{\tau_{is}^{\alpha}\pi_{is}^{\beta}}{\sum_{i=1}^{N}\tau_{is}^{\alpha}\pi_{is}^{\beta}} \quad 6$$

3. CASE STUDY

In this section, we solve the problem of an industrial engineering professor who needs to publish at least two papers per year. Table 1 shows the list of topics in which this professor is interested. For each topic, the professor checks the expertise in this topic such that familiar topics needs less time to work on. The professor checks the journals websties, in which he is interested to publish, and checks the publication probabilities. Lastly, the professor asks subject experts about the possible number of citations in the coming two years for the papers published in the targeted journals.

To solve this problem, we use the following parameters:

- $\alpha = 1$
- $\beta = 1$
- $\Delta\tau = 0.1$
- $\rho = 0.98$
- $\tau_{min} = 0.05$
- $\tau_{max} = 0.95$

As a termination criterion, we stop the algorithm after 1000 generation and each generation has 20 ants. The starting values of τ_{is} is 0.5, i.e., all arcs have equal probabilities of being selected. For the heuristic measure, π_{is}, we use a hybrid measure of ${}^{P_i}/_{t_i}$, as shown in the last column of Table 1. We try to increase the publication probability while spending the least time.

We solve the professor problem assuming a year worth of work. We assume that a year has 250 working days, of which, the professor would dedicate 80 days for teaching and community services. Thus, the professor has 170 days to work. Using our MMAS algorithm,this professor needs to select the following research topics: two papers about project management, and one paper about IoT, production planning, and transportation. This solution requires 160 days of work, it would be possible to publish 2.5 papers, and the expected citations is: 35.8.

Table 1. List of topics that the professor in the case study can research

Topic	Exeprtise	Research time (days)	Publication probability	Citations	Heuristic
Project management	Expert	20	60%	10	3
Supply chain	New	40	40%	20	1
IoT	New	60	30%	50	0.5
Block chain	New	50	25%	30	0.5
Production planning	Expert	20	40%	8	2
Fuzzy scheduing	Expert	25	30%	12	1.2
Transportation	New	40	70%	8	1.75

4. CONCLUSION AND FUTURE RESEARCH

This paper introduces a MILP that captures a professor problem who has a limited research time and needs to publish research articles. Moreover, improving the citation indices is also required from the professor. Thus, the professor needs to carefully select research topics to work on, knowing there is a probability of getting the written papers published. A new research topics would require more research time than a topic that the professor is familiar with.

We solve the MILP using a MMAS. For the heuristic information, we use a measure that consider the ratio of acceptance probability to research time. The MMAS was capable of finding the optimal solution for a case study problem presented in the work. Researchers can extend this work and consider other inputs to the problem based on the university or country context. For example, ability to get funding needs to be considered. Graduate student selection might also be included in the problem.

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