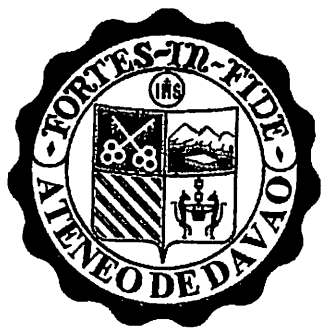
An Enhanced Hungarian Algorithm for the Taxi Assignment Problem



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An Enhanced Hungarian Algorithm for the Taxi Assignment Problem

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ABSTRACT

The Hungarian method is a time tested algorithm for solving assignment problems. It has a polynomial complexity, specifically, $O(n^3)$.

This study applied the Hungarian algorithm to the taxi assignment problem in a simulation. It incorporated real world variables like differing speeds on road segments, random road side passenger pickups and road closures.

The simulation engine consisted of a directed weighted graph that represented the road network, a predetermined number of taxi units available, a predetermined random roadside passenger pickup chance, a predetermined range n to m where n and m are the minimum and maximum numbers of passenger randomly inserted per a predetermined time window size.

The study also featured some customized improvements to the original Hungarian algorithm that improved the run time performance of the algorithm. The improvements became more apparent as the search space grew bigger when the number of taxis and/or the number of passengers were increased.

A notable achievement of the study was the ability of the algorithm to determine assignment in around 2 seconds given a search space with a size of 22,500 possibilities.

Keywords:

Taxi Assignment Problem, Hungarian Algorithm, Assignment Problem, Combinatorial optimization Problem, Simulation

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The assignment problem is one of the fundamental combinatorial optimization problems in operations research. Such problems usually involve deciding how to allocate resources in such a way that it produces the maximum results.

In the transportation sector, there are numerous manifestations of the assignment problem. Such problems can be found on courier companies, trucking companies, logistic companies, taxi companies and etc.

This study concerns itself specifically on taxi companies and their problems in assigning taxis to requesters. Some studies inaccurately model this problem as a routing problem. However, this problem can be more accurately represented as an assignment problem since unlike the routing problem; the problem does not concern itself primarily on the route to be taken.

Other studies have used the Simplex algorithm in solving this problem. However, the proponents believe the Hungarian algorithm is a much better choice since it has a better theoretical complexity.

1.2 Statement of the Problem

The taxi assignment problem is described as follows:

Suppose there are a number of phoned-in requests for a taxi originating at random locations and at random times and there is a fleet of taxis scattered at various locations. Assign taxis to the passengers in such a way that the assignment considers the location of the taxis, the location of each passenger, the traffic condition of the route, road obstructions and the maximum waiting time of each passenger.

Given the problem above, the study seeks to find the following:

1. How can the Hungarian algorithm be enhanced to accommodate the specifics of the taxi assignment problem?
2. How can a simulation be developed in such a way that it takes into consideration the traffic conditions and road obstructions generated in the network map?
3. What are the run time (in seconds, minutes or hours) of the application given certain set of test cases?

1.3 Objectives of the Study

The objective of the study is to implement the Hungarian algorithms in solving the Taxi assignment problem in a simulation. Specifically:

- to develop adaptations and implementations of the Hungarian that addresses the Taxi assignment problem.
- to ensure the adaptation addresses the constraints involved in the assignment

- to test the developed solutions in a parallel simulated environment
- to obtain and analyze the results
- to formulate a conclusion and draft a recommendation for future studies

1.4 Significance of the Study

The significance of the study lies in the fact that the taxi industry desperately needs to upgrade their operations systems. This old industry still has failed to capitalize on the ever advancing technology. The study sheds light on how the industry can utilize technology to increase operational efficiency by utilizing new technologies like GPS and mobile communication.

The study is also important since the prevailing algorithm of choice for this problem is still the slower Simplex Algorithm. By utilizing the Hungarian Algorithm, the proponents seeks to show that there are better alternatives.

1.5 Scope and Limitations of the Study

The scope of the study includes adapting and implementing the Hungarian algorithm to find the "optimal" or near-best solution for the taxi assignment problem. For this study, the optimal or near-best solution is achieved with a solution that satisfies all the defined constraints of the problem. The study will also include the development of a simulation environment wherein the various variables and constraints are generated and fed into the algorithms.

The study is limited and will not include real-life implementation (i.e. testing the software against with real taxis and real requesters). This is because

this kind of approach will prove to be expensive and out of the researchers current financial capabilities.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND WORKS

2.1 Common Real World Applications of Transportation Problems

a. Dynamic Fleet Management

Large scale trucking operations require real-time dispatching of vehicles for the purpose of collecting or delivering shipments. Important savings can be achieved by optimizing these operations (Brown et. Al, 1987).

b. Vendor Managed Distribution Systems

In vendor managed distribution systems, distribution companies estimate customer inventory level in such a way that they are able to replenish it before they run out of stock. Hence, demands are known beforehand in principle and all customers are static. However, because the demands are uncertain, some customers (usually just a small percentage) may run out of stock and have to be serviced urgently.

c. Couriers

Long distance couriers need to collect local outbound parcels before sending them to remote terminals to consolidate loads. Also, inbound loads have to be collected from remote terminals and distributed locally.

The deliveries form a static routing problem; because all recipients are known by the driver (and the dispatcher) before the vehicle leaves the depot. However, the pick-ups to be handled during the deliveries has the effect that makes the problem become dynamic in the sense that the driver and the dispatcher