Identifying real-life traffic problems and solving them using linear equations

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Abstract

Keywords:- Traffic Flow, Traffic Congestion, Mathematical Model

1. Introduction

The flow of traffic is a necessary component of our daily lives. There is not enough capacity on the road to handle all the cars at the same moment, resulting in road congestion. The major objective of our project is on how the orientation of traffic signals and other traffic control devices with the amount of traffic in a gateway can immensely support to aid traffic congestion or, in some cases, greatly reduce the flow of traffic. The following analysis of traffic flow over a road network during peak hours shows how a linear equation system and its answer works.

2. Background

The traffic flow of a network of streets can be analyzed using a system of linear equations. A graph is constructed from the data of vehicles passing through the intersection of streets. A system of equations is obtained from the graph, which is solved using matrix multiplication. In order to ease the process, 2 assumptions are made which are as follows:-

I. The streets must be one-way streets.
II. The number of vehicles traveling in opposite directions must be equal.

These assumptions will be useful to monitor the number of vehicles that should be allowed to pass through the streets so that the traffic of vehicles does not exceed a certain limit.

3. Motivation

Traffic jams have many severe effects on human health, the economy, and the environment. Due to traffic jams, the time to reach office, school or other places is increased, due to which there is a delay in working hours or study hours. If someone needs to reach immediately, in case of an emergency, the traffic jam can be very serious. As vehicles have to line up for a long time, fuel is wasted, and more CO_2 emissions increase air pollution. In such traffic jams, vehicles often need to be accelerated and braked, which in the long run damages the vehicle's engine. Due to air pollution, people are badly affected by

harmful gases, and driving in traffic causes mental stress and frustration to the person.

The present study aims to reduce the problem of traffic jams on four-way streets by calculating the number of vehicles required to pass through a one-way street.

4. Literature Survey

Men used to travel through rough paths and streets till the 18th century. As a result of urbanization, a web of roads spreads throughout the world, and vehicle companies produce more and more vehicles. Roads are the most basic medium of transportation in current time. This web becomes more and more complex. This leads to one of the most time-consuming problems - traffic.

We are going to solve this problem using the concepts of linear algebra. This concept has a good grab over multiplication applications. So, it is extended to other mathematical models too. That is the reason we decided on this topic as our problem statement.

In order to implement this project, we need a language to implement the logic of the mathematical model. So, we decided on python as a programming language because it has a rich set of libraries.

We always wonder how traffic reports are generated, how Google maps predict the traffic density of a particular road. After studying concepts of linear algebra, we concluded that we can also such mathematical models which are used by Google Maps.

5. Contributions

1. Raj Patel: He looked up the concept and ideas on the web and took part in team conversations to come up with an effective solution.

   - Reproduced work on your network flow analysis was done by him and Soham.

2. Manthan Patel: He looked at a lot of web pages and articles for ideas on how to solve the answers perfectly.

   -He was the mainframe for the plan of action of your project.

3. Vandan Shah: Designed the ppt for the final submissions along with technical focus and team morale.
   - He contributed the part of background, motivation.

4. Daksh Suthar: Along with his speed of execution single-handedly did the work of literature survey and references of the articles as well as helped a big-time during team chats.

5. Soham Jagrit: To not He contributed thoughts and suggestions to the project. Spend a significant amount of time advising other members on particular tasks involving their knowledge in their field.

6. Mathematical Model

We are using linear equations to

solve real-life traffic problems of Andheri East, Mumbai. We are focused on mainly 2 traffic problems, which are as follows:

I. Our plan is to find traffic rates at a particular path given vehicle rates at source and sink nodes.

II. In real life, there are situations where due to some function, rally, or marriage one road is blocked. In this situation, what will the effect of traffic on other roads? We will try to answer this question.

The network of traffic is as follows:

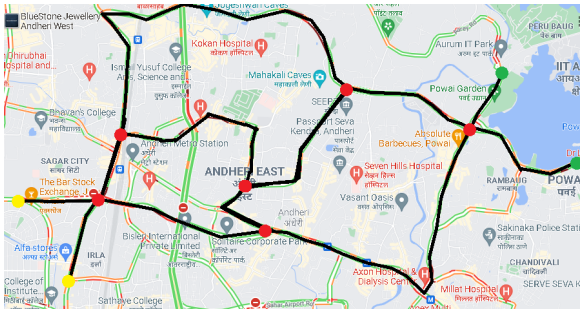

Image 1.

In this picture(Image 1),

Red dots represent intermediate nodes,

Yellow dot represent source nodes and,

Green dots represent sink nodes.

Vehicles enter from source nodes and leave the network at sink nodes.

Graphical representation of the network is as follows:

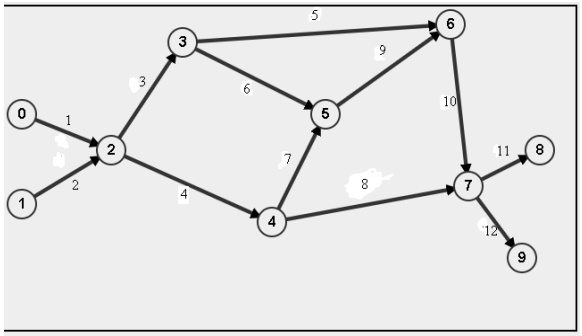

Image 2.

Nodes represent Junctions:

1. Mahindra NBS International
2. DCB Bank
3. Honda Big Wing Mumbai - Sales
4. MIDC
5. Speez village
6. Sakinaka Traffic Division

Paths represent roads: (vph - vehicles per hour)

1. CD Barfiwala road (2500)
2. Swami Vivekananda road (1700)
3. Swami Vivekananda road (a)
4. Professor NS Phadke road (d)
5. Jogeshwari – Vikhroli Link road (b)
6. Mahakali caves road (c)
7. Andheri road (e)
8. Saki vihar road (x)
9. MIDC central road (z)
10. Jogeshwari – Vikhroli Link Road (y)
11. Saki vihar road (1600)
12. The view road (2600)

Numerical calculations:

Problem 1:

a + d = 4200;

a - b - c = 0;

d - e - c = 0;

c + e - z = 0;

b + z - y = 0;

x + y = 4200;

Now to solve these linear equations, we will first form an augmented matrix. We will convert the augmented matrix to echelon form using row operations. Finally, we will convert it to a reduced row echelon form using row operations.

Augmented matrix:

a	b	c	d	e	x	y	z	-
1	0	0	1	0	0	0	0	4200
1	-1	-1	0	0	0	0	0	0
0	0	0	1	-1	-1	0	0	0
0	0	1	0	1	0	0	-1	0
0	1	0	0	0	0	-1	1	0
0	0	0	0	0	1	1	0	4200

Reduced row echelon form:

a	b	c	d	e	x	y	z	-
1	0	0	0	1	0	-1	0	0
0	1	0	0	0	0	-1	1	0
0	0	1	0	1	0	0	-1	0
0	0	0	1	-1	0	1	0	4200
0	0	0	0	0	1	1	0	4200
0	0	0	0	0	0	0	0	0

Here e, y, and z are non-pivot columns. So, e, y, and z are free variables.

a = y - e;

b = z - y;

c = z - e;

d = 4200 + e - y;

e = e;

x = 4200 - y;

y = y;

z = z;

Problem 2:

For solving this problem, suppose path b(5) removed. We are left with 4 intermediate node problem which is solved by the above-shown method.

Here, we can assume, a = c = p and z = y = q;

p + d = 4200;

d - e - x = 0;

p + e -q = 0;

q + x = 4200;

Augmented Matrix:

p	d	e	q	x	-
1	1	0	0	0	4200
0	1	-1	0	-1	0
1	0	1	-1	0	0
0	0	0	1	1	4200

Reduced row echelon form:

p	d	e	q	x	-
1	0	1	0	1	4200
0	1	-1	0	-1	0
0	0	0	1	1	4200
0	0	0	0	0	0

Here e and x are non-pivot columns. So, e and x are free variables.

p = 4200 - e - x;

d = e + x;

e = e;

q = 4200 - x;

x = x;

6. Numerical Results

Problem 1: result

Lets assume e = 400; y = 900; z = 1200;

a = y - e = 500;

b = z - y = 300;

c = z - e = 800;

d = 4200 + e - y = 3700;

e = e = 400;

x = 4200 - y = 3300;

y = y = 900;

z = z = 1200;

Path d and x are the most congested roads;

Problem 2: result

Lets assume e = 1200; x = 900;

a = c = 4200 - e - x = 2100;

d = e + x = 2100;

e = e = 1200;

y = z = 4200 - x = 3300;

x = x = 900;

Path y is the most congested road and paths a, c, and d are equally congested roads.

7. References

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[5] Graph made and edited in: https://visualgo.net/en/maxflow

[6] For more clear images click the below link https://drive.google.com/drive/folders/1O2hcIQ2t7UlBA2WlPpZxHiMu-Znvetc5?usp=sharing